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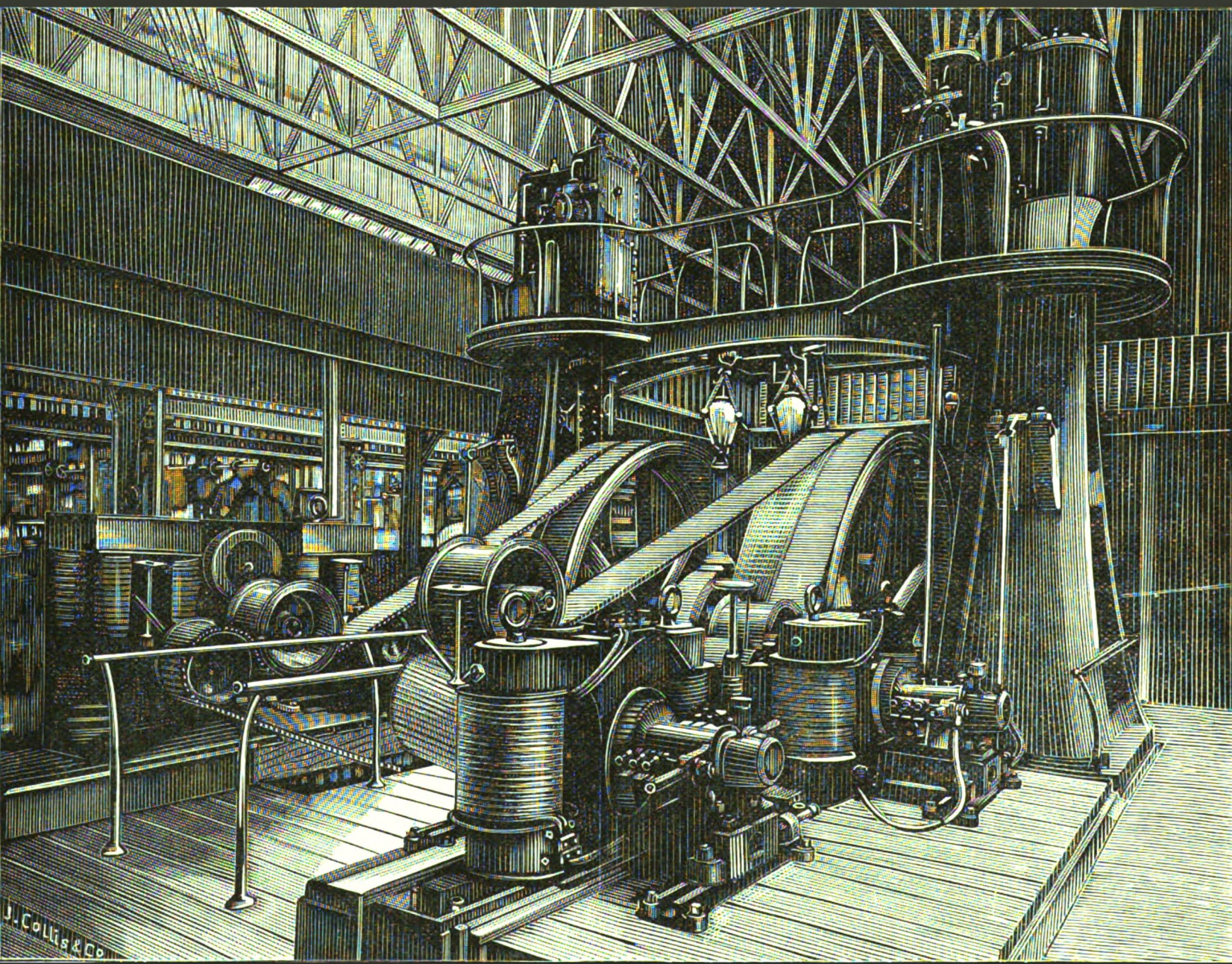

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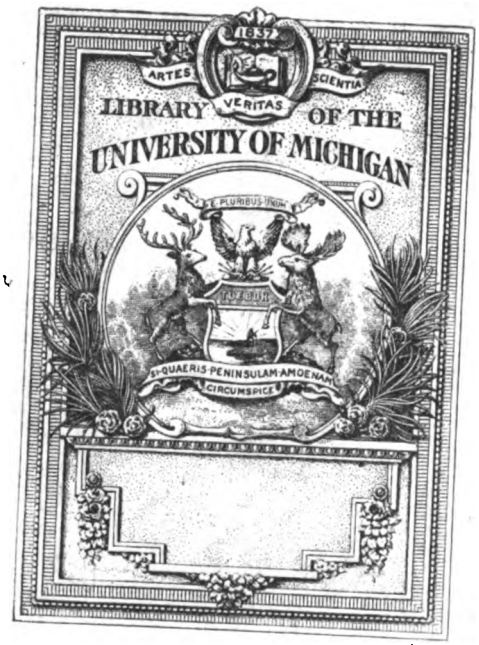

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THE ELECTRICIAN:

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NOTES.

Hamburg.—The German Government are constructing a special line exclusively for the telephone between Hamburg and Kiel.

Poland.—The Russian Government is said to be taking steps to connect the whole of the fortresses in Russian Poland by means of subterranean lines.

Geneva.—An electric tramway is projected between Geneva and the little town of Coppet. A concession will shortly be granted to an electric lighting company guaranteeing them a monopoly in Geneva for nine years.

The French Academy.—We regret to announce the death of M. Gosselin, the President of the French Academy. M. Gosselin was a member of the section of Medicine and Surgery, in which departments he had attained a high scientific fame.

Royal Institution.—The following are the titles of the lectures delivered by Prof. W. E. Ayrton, F.R.S., on April 26, May 3, and May 10:—"The Cost of Electricity," "Apparent Momentum of Electricity Produced by Magnetic Inertia," "Self and Mutual Induction, and their Bearing on the Question of the Economic Distribution of Electrical Energy."

The Royal Institution.—The Chair of Natural Philosophy at the Royal Institution, vacant by the resignation of Prof. Tyndall, has been accepted by Lord Rayleigh. The title of Honorary Professor of Natural Philosophy has been conferred by the Institution on Prof. Tyndall. The appointment of Lord Rayleigh will be received with satisfaction by the whole scientific world, and is especially gratifying to electricians.

Vienna.—Messrs. Getz and Odendall have recently obtained orders for some batteries of their largest sized accumulators of the Farbaky-Schneck type. The firm of Kremenetzky and Mayer (the Brush Company) also talk of manufacturing accumulators of the E.P.S. type in Vienna. It will be interesting to see what may be done by either of the above firms as regards the question of patents if the latter proposal of the Brush Company is carried out.

A Remarkable Motor.—We have been favoured with the following description of an electromotor, which we reproduce as received:—"It is of recent type, double-armoured armature, working on 30 amperes and 100 volts, and containing compensating cylinders and elaborate cut-outs for the very varying pressure required. The nicety of finish remarkable in this machine enables it to produce at least 15,000 ohms, and being driven at 150lb. to the square inch gives out 95 per cent. of the initial energy. A very difficult problem is evidently nearer solution, as our electricians will see."

The Caoutchouc Species.—Mr. Bruce Warren, recently lecturing before the Society of Arts, stated that the sap of the *Syphonia elastica* (a plant indigenous to the climate of Para) frequently contains free ammonia. He attributed this fact to the silent discharges of atmospheric electricity, which take place at night from the branches of the trees and are easily observed. Other plants of the same order as the *Masaraudubæ* (cow tree) and the *Mangabeira* (mango tree) do not develop free ammonia in their sap under the same conditions. He thought that the two latter trees could be introduced with advantage into many of our colonies.

The Society of Arts.—The Society of Arts have recently laid down an Immisch series-wound electric motor for lecture and general purposes. The machine is of the well-known Immisch type. The field connections are arranged so that the coils can be coupled in series or parallel. This arrangement is necessitated by the variety of work which the motor has to do. The maximum output is 3 brake horse-power at 950 revolutions per minute. The E.M.F. required is 110 volts, and so the motor can be run in parallel with the incandescent lamps used to light the large hall. It is found to be a valuable addition to the society's plant, and enables many lectures to be illustrated in a very practical way.

Antwerp.—Some time ago M. Nothomb succeeded in launching a company for supplying the City of Antwerp with electric light. This new undertaking was, however, immediately attacked by the gas company, who claimed to possess the exclusive right to light the town until the year of grace 1912. The action has been carried from court to court, but the final Court of Appeal at Brussels has now decided in favour of the claims of the gas company. The commiseration of the whole civilised world—even of London itself—may well be extended to this unfortunate city, doomed without hope of release, except from the goodwill of the company, to see by gas flames for another quarter of a century.

The Latest Accumulator.—For all purposes where accumulators have to be carried about, for tramcars, and, above all, for miners' lamps, this battery will prove—if only the claims of the inventors be verified—to be absolutely without a rival; its name should at least be the *Sans Pareil*, or even the *Ne Plus Ultra*. Our enthusiasm will be appreciated when we state—on the authority of the inventors H.H. Haefner and Langhans—that the E.M.F. of a single couple amounts to as much as 3·2 volts. Henceforth, a lamp of 12 candles may be maintained alight at full power for the space of three hours by means of a battery measuring 1 cubic decimetre—so at least we are told. The negative plate of this cell is formed of a mixture of peroxide of manganese and protoxide of lead. The positive plate consists of an amalgam of "the heavy metals." (? An, Pt, Ir, Os, &c.) The solution is alkaline.

Lighting at Vienna.—The Imperial Continental Gas Association have now obtained the permission for laying their

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cables between the Central Station Schenkenstrasse, No. 10, and the Opera House and new Burg Theatre. Several of the very objectionable clauses in the conditions, which were previously proposed and to which we have referred, have been either altogether omitted or much modified in the accepted agreement between the Imperial Continental Gas Association and the Geminderath, although the exceedingly high yearly tax is still imposed. The cables are to be supplied by Messrs. Chaudior and Co., who are manufacturing in Vienna, under the patents of Berthoud-Borel ; a high insulation resistance has been specified. The Opera House will probably now be closed for a month during the summer to allow of the final alterations to light fittings, &c., and will be reopened about August 1. The building of the new Burg Theatre will not be completed until some time in 1888, so that it will be electrically lighted from the commencement of its career.

Determining the Flashing Point of Mineral Oils by Electricity.—The "flashing point" of a mineral oil is the temperature at which the liquid begins to give off inflammable vapours. In America, this point is determined by a simple electrical method known under the name of the Seybolt process. The mineral oil is placed in a vessel, open at the top, and heated by means of a water-bath. A thermometer stands in the oil, and a pair of electrodes at a fixed distance apart hang just over the surface of the liquid. By means of a small induction coil a spark is passed between the electrodes, and the temperature of the water bath being gradually increased, the reading of the thermometer is taken at the instant that the vapour takes fire. It is, however, said that this method does not yield very concordant results, and as the industry is in America one of enormous importance, it would probably be worth while to devise some improvements in carrying out the details ; it is probably difficult to get an accurate reading of the thermometer with the present arrangements.

Secondary Battery Questions in Belgium.—A correspondent at Brussels writes as follows :—The employment of accumulators is on the increase in this country, although unhappily the industry is hampered by the number of various "systems" now in competition, and by the eternal question as to the right to the use of red lead applied mechanically. Thus, at Brussels, M. Julien, who is the managing director of the Cie l'Electrique, makes use by turns of his personal claims for the metallic composition of the supports (lead-antimony-mercury) and of those of his company for the combination of a support and of material supported. Nevertheless, the use of oxide of lead is certainly open to the public, since it has been shown that M. Planté had employed this method in the course of his researches long before M. Faure had dreamt of his patent. So that at best M. Faure could only claim the method of attaching and retaining his red lead—which no one now envies him. Yet it is by means in this direction periodically renewed that it is sought to shut the public out of the free use of Planté's discoveries. It is probable, however, that the game will prove an unprofitable one in the long run.

Preservation of Wooden Poles.—A simple method of treating wood with preservative solutions is employed in Norway for telegraph poles. After the poles are set in place a man goes from one to another with an augur, with which he bores a hole in each post, beginning at a point about 2ft. above the ground, and boring obliquely downward, at as small an angle as possible, with the axis of the post, until the point of of the augur reaches the centre of the stick. The auger-hole should be an inch in diameter, and, in telegraph poles of the ordinary size, will hold easily 4 to 5 ounces of sulphate of copper, which is put into it in the form of coarsely powdered crystals, and the opening then stopped with a plug, the end of which is left projecting as a handle, so that it can be pulled out and replaced. Just what action it may be that then goes on in the interior of the stick no one pretends to say ; but it is found that the crystals of copper sulphate disappear slowly, so that every three or four months the charge must be renewed ; while the wood, both above and below the auger-hole, even to the very top of the pole, gradually assumes the greenish tint due to the presence of copper in the pores.

Electric Lighting on Board Forth Passenger Steamers. On Saturday, May 7th, a large company of gentlemen met, being invited by Mr. M. P. Galloway, Leith, to witness the official trials of the installations fitted on board the ss. "Lord Morton" and "Edinburgh Castle" by Mr. Rankin Kennedy, of Glasgow. The dynamos are of Kennedy's new ironclad type, and are run at a speed of 800 revolutions per minute, driven by "Archer" engines from the fly-wheels with Dick's patent gutta percha and canvas belts. The "Lord Morton" has 35 and the "Edinburgh Castle" thirty 20 candle-power Swan lamps. The fittings in saloons and cabins are silver-plated, of a neat design, with cut glass globes. Each fitting has a switch, so that the light can be turned off and on at will. Each steamer has a deck lantern (portable) with five 20 candle-power lamps to be used in landing and embarking passengers and luggage at the various piers at night. The installations have been fitted up under the superintendence of Mr. James Campbell, of Mr. Kennedy's firm. After various tests, the results obtained were to the entire satisfaction of Mr. R. Young, the superintendent-engineer, and Mr. Galloway, the owner, who have two other steamers being fitted up by Mr. Kennedy in a similar manner.

Earthquake Speculations.—The origin of earthquakes has been the subject of much speculation and many theories, not a few of which have included the factor of electricity as a prominent cause. Recently again Ch. Naudin, in *Comptes Rendus*, suggests that earthquakes may be due to the greater or less resistance which certain parts of the earth's crust present to the electric currents generated within the globe. He points out further, or asserts, that the countries visited by earthquakes are devoid of forests, which would favour the escape of the electricity. In a somewhat similar manner Mr. George O'Brien, writing in the American *Mining Journal*, distinguishes most of the earthquakes that occur on the western coast of South America as arising from the local action and volcanic exhalations in the Andes causing electrical currents down the valleys from east to west, and under the "made ground," which is derived from constant wearing down of the mountains. "The electric current travelling on the firm rock, conducted by the moisture and water lying upon it, and thus in contact with the material possessing for it the greatest powers of conductivity, and from such fulcrum and firm basis the current shakes the made ground above it, with buildings thereon, the electric fluid then escaping into the atmosphere, animating all nature and eventually causing when in excess thunder and lightning." The latter "theory" is somewhat involved, but the idea embodied in both those cited appears to be that the variable electrical tension in different parts of the earth's crust creates a condition which, under certain circumstances, causes a stress sufficient to overcome the normal state of equilibrium. As to the point about the absence of forest, that seems open to question. The West Indian Islands and South American regions subject to earthquake are generally, and in some cases superabundantly, provided with trees.—*Electrical World.*

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EXPERIMENTS WITH HIGH-TENSION ELECTRICITY.—It is well known that by means of a suitable commutator, driven by clockwork or otherwise, and connected with a condenser, the plates of which are alternately charged in parallel and discharged in series, a very high tension may be attained with only a single battery cell as the original source of electricity. The apparatus is, however, more expensive, and even more likely to suffer damage than the modern forms of static induction machines, so that it is very seldom employed in this country. In France, however, the rheo-static machine has always received more favour, and an account of a series of experiments, some of which at least are new to us, carried out with one of these machines, appeared recently in our contemporary *Electricité*. One advantage of the rheostatic machine is that the E.M.F. between the discharging points can be closely calculated if we simply know the E.M.F. of the source, the capacity of each pair of plates, and the number of pairs of plates in the condenser. However, no estimate as to the E.M.F. required for the following experiments is found in the paper. Let a small glass beaker be filled with salt water, and into this dip a platinum wire connected with one electrode. Take a capillary tube open at both ends, pass a platinum wire through it connected with the second electrode, and dip the tube and wire under the surface of the liquid. In all these experiments, if a static induction machine be employed, the circuit must be continually made and broken elsewhere either in shunt or series; then, on setting up the interrupted difference of potential, a brilliant spark is seen at the lower extremity of the tube, and the liquid rises a little at each discharge, attaining a height of 0·25m. to 0·30m. The action is just like that of an hydraulic ram. If the height of the tube be less than that to which the liquid could attain naturally it overflows at top, but in doing so the drops pass out of the circuit and therefore again break forth into flashes and gleams of fire. In the dark the experiment is a very effective one. Next let the beaker be exchanged for an open dish, and take a very short piece of tubing, say about an inch in length. Then on arranging everything else as before, taking care, however, that the tube dips about half its length under water and that the platinum wire passes *very nearly* right through it, on starting the discharge a fine jet of water is thrown up to the height of about a metre. The noise made by the sparks in this experiment is extremely loud, and the concussions are so violent that the glass vessel is sometimes broken. The experiment is more successful if the wire which enters the liquid without passing through the tube be insulated, except at its extremity. If this be not done a good deal of water is scattered about. This wire should also be the positive pole. If it is made negative the jet is scarcely half as high. A brilliant flaming discharge, giving deafening explosions, may be obtained by allowing the platinum wire to enter at the lower end of a rather short capillary tube (still under water), and to pass nearly to the top; then let the other electrode be brought over the top of the tube. It seems probable that this flame is in part due to the separation and recombination of the elements of water.

HISTORY OF THE SIMULTANEOUS TRANSMISSION OF MESSAGES BY ONE LINE WIRE.—The recent issue of the *Journal* of the Society of Telegraph-Engineers contains the following abstract of an article which appeared in *La Lumière Electrique*, October 23rd, 1886:—"In an English patent, No. 12,959, of the 7th February, 1850, Highton points out the possibility of using ordinary battery currents for working the instruments, whilst currents from electro-magnetic generators might be used for actuating sounders. Werner Siemens, in 1856, proposed the simultaneous sending of ordinary battery currents, and of alternate currents produced by a magneto-inductor, over the same wire. The ordinary currents would act on any electro-magnets in the circuits, but these latter would be unaffected by the alternate currents, which could, however, act on an electro-dynamometer used as a relay. Isham Baggs, in 1858, took out a patent for an arrangement for triple working. He used a magneto-electric current for deflecting a needle, a very powerful current which could have a chemical action on prepared paper, and very high tension currents which could perforate holes in paper strips. The patent of Hughes, taken out in 1858, is also for the combined use of battery currents and of induced currents. In 1871, Whitehouse proposed to make use of earth currents in conjunction with battery currents, each actuating its special instrument. As he puts it, the earth currents can be compared to the deep waves of the sea, slow and gradual in their motion, while the battery currents resemble ripples on the surface. Varley's patent, No. 1044, of 1870, is the forerunner of a great number of subsequent apparatus. He made use of rapidly undulating currents superposed on the ordinary currents, the former actuating special harmonic sounders. In 1876 Elisha Gray patented a combination of harmonic telegraphs with ordinary Morse instruments, which, in 1878, was modified by the introduction of telephones in the place of harmonic telegraphs. It is to the patent, No. 1477, of 1879, taken out by Messrs. Black and Rosebrugh, that we have to look for the first arrangement of two parallel telegraphic wires as a telephonic circuit. The telephones are interposed between the earth and a condenser, which stops the battery currents while it allows the passage of the undulatory telephone currents, and of alternate currents for ringing up. In this same year, 1879, we have Edison's American patent, No. 217,781, in which an arrangement is described capable of producing three variations of current. There is a key for reversing the current, a second for making variations in the strength of the current, and a vibrating reed for producing an undulatory current. Field's American patent, No. 242,411, of 1881, treats of a sextuple telegraph; two keys vary the intensity of the current, and a third produces harmonic vibrations; the receiving instruments are arranged to answer to each kind of current. Coming now to more modern systems, we have Van Rysselberghe's plan of combined telegraphy and telephony; similar plans by Maiche and Van der Weyde; a combination of the telegraph with the phonophore by Langdon Davies; and two duplex telegraphic systems, one by Edison and the other by Rosebrugh."

THE INFLUENCE OF MAGNETISM UPON CHEMICAL REACTIONS.—This is a subject of very considerable interest, and one in which, although very little work has yet been done, will probably well repay systematic investigation. The effects described below are not, we believe, absolutely new, although they are recorded by M. Colardeau in the last number of the *Journal de Physique*, and evidently under the impression that they are now given for the first time. But even if this be not the case the results will bear repetition. M. Colardeau takes a thin sheet of iron, underneath which the poles of a powerful magnet are placed. Copper is then deposited upon the iron from a solution of sulphate, when it is found that the deposit, instead of being of even depth over the surface, is cut up into numerous ridges. These ridges do not follow the magnetic lines of force, but are at all points orthogonal to those lines; they are, in fact, lines similar to those which the same investigator has found to be traced out by substances of low magnetic power when strewn in the form of powder over the magnetic field. (See *Electrician*, March 18th, p. 411). The hypothesis by which M. Colardeau at first attempted to

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explain the effect was the following:—The deposit of copper from the solution of sulphate is in itself (in all probability) an electro-chemical phenomena, and may be considered to be due to a great number of extremely minute local couples, between which currents of electricity actually circulate. If this be the case, then these currents, under the influence of the magnet, will set up minute eddy currents in the liquid, which currents will be directed normally to the lines of force, and copper will be deposited chiefly along such streams. If, however, this explanation be correct, the plate of iron plays no necessary part in the reaction, or at least it might be replaced by a sheet of some other metal which is capable of reducing a copper salt. Acetate of copper and zinc should, for instance, give the same results; but, on making the experiment, a perfectly uniform deposit was obtained, and no trace was visible of the magnetic field. The first hypothesis must therefore be abandoned. The following considerations lead, however, to the establishment of a more consistent theory:—We know already (and a reason has been assigned in the note quoted above), that substances of low degrees of magnetic permeability tend to distribute themselves in the magnetic field in lines orthogonal to the lines of force. Now, during the chemical action, while copper is deposited, sulphate of iron is formed; but sulphate of iron is a substance of low magnetic permeability, hence it tends to form liquid filaments (if the term be permissible) which will lie along the direction already indicated. These filaments will exert a protecting influence upon the iron underneath, and will cause the copper to be deposited in ridges between them, and following, therefore, the same lines of direction. If this explanation be correct, the formation should be prevented by keeping the liquid in a state of agitation; and this is found to be the case. But M. Colardeau goes further than this, and renders the formation of the liquid filaments actually visible. In order to do so it is merely necessary to employ some salt of copper whose colour differs very distinctly from that of the corresponding iron salt. The best effect is produced by means of an alcoholic solution of bichloride of copper, which is green, while ferrous chloride is a deep yellow colour. The striæ formed by the iron salt are then clearly visible.

PROPOSED ABSOLUTE UNIT OF TIME BY ELECTRICAL MEASUREMENT.—The fact that our present system of measuring the flight of time, based, as it is, fundamentally upon purely astronomical observation, is not so rigorously exact as it was once supposed to be, is undeniable—and regrettable. Poisson was thought to have proved that a change in the length of the sidereal day amounting to one ten-millionth part in 2,500 years was incompatible with the occurrence of an ancient eclipse which the Chaldeans have recorded in their sculptures; and similar calculations were made by Laplace. But, alas! these great mathematicians were in error. It is not so. Slowly but surely the recurring tides are putting an effective drag upon the whirling earth, and it is calculated that already the day is longer from this cause than it was in the year 720 B.C. by as much as one part in 2,700,000. But this is not all; the velocity of the diurnal rotation of the earth is necessarily affected by anything which disturbs its moment of inertia about the axis of rotation, and this we know must be continuously diminishing—and, therefore, the velocity is being retarded—by reason of the secular cooling of the earth and its accompanying contraction in bulk. Only last week we read that a mountain peak in Arizona had been overthrown, and it is a mournful aggravation of the calamity to know that thereby the value of our present standard of time has been altered to an unknown and an unascertainable extent. The ceaseless fall of meteoric dust is a cause of still further discrepancy. Can nothing be done? How long shall science labour under the reproach that our fundamental unit of time is not constant even if ascertainable? The reproach cuts even more deeply when it is recognised that, for certain of the very same causes as we adduced above, the unit of mass labours under a similar charge of inconstancy, while, as for the unit of length, it has long relinquished even the pretence of having any foundation in Nature. It is true that many years ago Prof. Clerk-Maxwell expressed the opinion—an opinion in which we still venture with deference to concur—that the science of the future would base its fundamental units of length and time upon the exactly ascertained wave length and period of vibration of one selected light ray *in vacuo*. The conception is worthy of the genius of Maxwell, though even here we must perforce admit that a painful doubt creeps in. Who shall assure us that in the course of time the structure of the ether itself shall not undergo modification? At this point, as at so many others, the unwelcome conviction is forced upon us that it is the *relative* alone in which the human mind finds its appointed field of action—the absolute is synonymous with the unknowable. Failing, then, a loftier flight, does it not still remain a wise and legitimate quest to seek to attain as nearly as may be at least to constancy and accuracy in our standards? So, at least, thinks M. Lippmann, and far be it from us to dispute the proposition. M. Lippmann is also in all probability correct in tacitly assuming that the time has not yet arrived when Maxwell's suggestion can be adapted as a practicable scheme. He has therefore undertaken a new and thorough consideration of the subject—and this, it should be remembered to his credit, before the announcement of the fall of the Arizonian mountain peak—with the result that in a brilliant note recently presented to the French Academy he proposes a solution which is practically the following:—M. Lippmann, while retaining the element of time as one of our fundamental units, would make its value depend directly upon our knowledge of the unit of length. We have all been taught from our earliest (electrical) infancy that electrical resistance has the same dimensions as velocity. Sometimes, indeed, we say that resistance *is* a velocity, and then it is to be feared that we tend to get a little mixed. Now a velocity, it is needless to observe, *is* a length divided by a time; consequently, by a slight effort of the mathematical imagination it will become equally clear that the reciprocal of a velocity when divided by a length must be an expression signifying a time interval. We have also to observe with equal care that in the inscrutable wisdom of the physicists who have devoted their talents to the development of Fourier's "Theory of Dimensions," it has been decreed that resistance, while possessing always the same dimensions, should be expressed in *electrostatic* units, not directly as a velocity but as the inverse thereof. Once more, the *specific* resistance of any substance is a quantity which must necessarily vary directly with the unit of length. But it has been shown (axiomatically) that the reciprocal of a velocity divided by a length yields a definite period of time. Now, therefore, it is abundantly clear that making only the assumption that the specific resistance of a given substance, measured electrostatically, is an absolute and invariable quantity, then the electrostatic measurement of the specific resistance of any such substance yields AN ABSOLUTE MEASUREMENT OF TIME. Thus is our fundamental measurement of "the great independent variable," which Hobbes defined as "the phantasm of before and after," rescued from the accident of toppling crags or flowing tides, and securely based on the verification of the unit of length and the accurate determination of the electrostatic resistance of a cubic centimetre of mercury.

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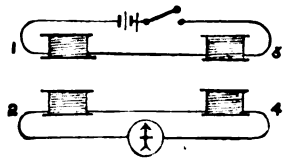
ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXIX.

BY OLIVER HEAVISIDE.

(Continued from page 459, Vol. XVIII.)

Felici's Balance Disturbed, and the Disturbance Equilibrated. Theory of the Balance of Thick Wires, both in the Christie and Felici Arrangements. Transformer with Conducting Core.

Referring to the last figure, in which imagine the galvanometer to be replaced by a telephone, and the key by an automatic intermitter, let us start with a perfect balance due to the M of one pair of coils being cancelled by the M of the other pair, and consider the nature of the effects produced by the presence of metal in or near either pair of coils.



First, let 3 and 4 be the coils of an inductometer, and 1, 2 other coils of any kind, separate from one another. The simplest action is that caused by non-conducting iron. It acts to increase or decrease the M of either or both pairs of coils according to its position with respect to them, and its effect can be perfectly balanced by a suitable increase or decrease of the M (mutual inductance) of the inductometer coils. Suppose, for example, the disturber is a non-conducting iron bullet, and is brought into the field of the coils 1, 2. If it be inserted in either coil, it increases their M. This is mainly because it increases the L of the coil in which it is inserted. If the two coils have their axes coincident, as in the figure, the bullet will cause their M to be increased by placing it anywhere on this axis, or near it. But if the bullet be brought between the coils laterally, so as to be, for instance, between the numerals 1 and 2 in the figure, the result is a decreased M. Here the L of each coil is little altered, and the decrease of M results from the lateral diversion of the magnetic induction by the bullet from its normal distribution. By pushing it in towards the axis a position of minimum M is reached, after which further approach to the axis causes M to increase, ending finally on the axis with being greater than the normal amount.

If the disturber be a non-conducting core (round cylinder), the greatest increase of M is, of course, when it is pushed through both coils, which are themselves brought as close together as possible, and when the core itself is several times as long as the depth of the coils. M is then multiplied about four times when the coils are about of the shape shown, with internal aperture about $\frac{1}{3}$ the diameter of the coils. If the coils be wound parallel on the same bobbin, the increase is much greater. If the whole space surrounding the coils be embedded in iron to a considerable distance, we shall approach the maximum M possible. The effective inductivity of the non-conducting iron is considerably less than that of solid iron, which counterbalances the freedom from F. currents.

Using solid iron, no silence is possible, owing to the F. currents, although there is a more or less distinctly marked minimum sound for a particular value of M. The substitution of a bundle of iron wires reduces this minimum sound, and when the wires are very fine, it is brought to comparative insignificance; but only by very fine division of iron are the F. currents rendered of insensible effect. It will be, of course, remembered that the range of the magnetic force variations must be moderate, so as to render the variations in the magnetic induction strictly proportional to them, otherwise no perfect balance is possible with non-conducting iron.

On the other hand, non-conducting (*i.e.*, very finely divided) brass (or presumably any other non-magnetic metal) does nothing. Diamagnetic effects are insensible. The above remarks apply, for the most part, equally well to the self-induction balance, except that iron always increases the L of a coil.

So far is very simple. It is the effect of the conductivity (in mass) of the disturbing matter that makes the interpretation of results troublesome. If the disturber be non-magnetic, we have a secondary current due to the action on the secondary circuit of the current induced in the disturber by the primary current; at least I suppose that this is the way it might be popularly explained. If the disturber be not too big, the M of the inductometer which gives the least sound (instead of silence) is sensibly the old value which gave silence before its introduction. If it be magnetic, there is also usually increased M. Changing the M of the inductometer to suit this, the minimum sound is still far louder than with an equally large non-magnetic disturbing mass (metallic) because the F. currents are so much stronger in iron. To this an exception is Prof. Bottomley's manganese steel of nearly unit inductivity, in which the F. currents should be, and no doubt are, far weaker than in copper, on account of the comparatively low conductivity. If this be not so, then it must be found out why not. Again, if the iron be independently magnetised so intensely as to reduce the effective inductivity sufficiently, then, as I pointed out in 1884, the F. currents should be made less than in copper.

To obtain an idea of the disturbance in the secondary circuit due to a conducting mass, let it be a simple linear circuit, and call it the tertiary. Let the suffixes $_1$ and $_2$ refer to the primary and secondary circuits, and $_3$ to the tertiary. Then the equations of E.M.F. are

$$\left.\begin{aligned} e &= Z_1C_1 + M_{13}pC_3, \\ 0 &= Z_2C_2 + M_{23}pC_3, \\ 0 &= M_{31}pC_1 + M_{32}pC_2 + Z_3C_3; \end{aligned}\right\} \quad . \quad . \quad . \quad (21c)$$

where $Z = R + Lp$, and e is the impressed force in the primary. Here M_{12} is missing, it being supposed to be properly adjusted to be zero. From these,

$$C_2 = \frac{M_{13}M_{23}p^2e}{Z_1(Z_2Z_3 - M_{23}^2p^2) - Z_2M_{13}^2p^2} \quad . \quad . \quad . \quad (22c)$$

is the secondary current's equation. The secondary current therefore varies as the product of the M of the tertiary and primary into the M of the tertiary and secondary. It is therefore made greatest by making coils 1 and 2 in the figure coincident (practically) by double-winding, and putting the disturber in their centre. In this case let R and L be the resistance and inductance of the primary and also of the secondary circuit, r and l those of the tertiary, and m the former M_{13} or M_{23}, now equal. Then (22c) becomes

$$C_2 = \frac{m^2p^2e}{zZ^2 - 2Zm^2p^2} \quad . \quad . \quad . \quad . \quad (23c)$$

But m is very small compared with L, so

$$C_2 = \frac{m^2p^2e}{zZ^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24c)$$

Let the impressed force be sinusoidal; then $p^2 = -n^2$, making

$$C_2 = -\frac{m^2n^2e}{(r+lp)\{(R^2 - L^2n^2) + 2RLp\}}, \quad . \quad (25c)$$

Let $R = Ln$, which is a readily approximately reached condition. Then

$$C_2 = \frac{m^2}{2RL} \cdot \frac{ln^2 + rp}{r^2 + l^2n^2} \cdot e \quad . \quad . \quad . \quad . \quad (26c)$$

gives the secondary current in amplitude, $m^2n/2RL(r^2 + l^2n^2)^{\frac{1}{2}}$ per unit impressed force, and phase. If the tertiary could have no resistance, the secondary current would be of amplitude $m^2/2RL$ per unit impressed force, and in the same phase with it.

Now seek the conditions of balance by means of a fourth linear circuit placed between coils 3 and 4 in the figure, supposed to be identical with coils 1 and 2. Let the suffix $_4$ relate to this fourth circuit. Then (21c) become

$$\left.\begin{aligned} e &= Z_1C_1 + M_{13}pC_3 + M_{14}pC_4, \\ 0 &= Z_2C_2 + M_{23}pC_3 + M_{24}pC_4, \\ 0 &= M_{31}pC_1 + M_{32}pC_2 + Z_3C_3 + Z_4C_4, \\ 0 &= M_{41}pC_1 + M_{42}pC_2 + Z_4C_4, \end{aligned}\right\} \quad . \quad (27c)$$

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Here, besides M_{12}, M_{34} is also missing, because of the distance between the two disturbers. From these,

$$\Delta C_2 = (M_{23}M_{31}Z_4 + M_{24}M_{41}Z_3)e \quad . \quad . \quad (28c)$$

is the equation of C_2, where Δ is the determinant of the coefficients in (27*c*). For a balance, the coefficient of e must vanish. This gives

$$\frac{r_3}{r_4} = \frac{L_3}{L_4} = -\frac{M_{31}M_{32}}{M_{41}M_{42}} \quad . \quad . \quad . \quad . \quad (29c)$$

If the coils of each "transformer" are coincident and equal, $M_{31} = M_{32}$, and $M_{41} = -M_{42}$; and, the M's being small, (28*c*) becomes

$$C_2 = \frac{M_{31}{}^2Z_4 - M_{41}{}^2Z_3}{Z^2Z_3Z_4}e, \quad . \quad . \quad . \quad (30c)$$

where Z is that of either the primary or secondary circuit.

We do not need to balance the disturber in one pair of coils by means of a precise copy of it in the other pair, similarly placed. It may be a reduced copy, according to (29*c*).

(To be continued.)

ELECTRICAL MEASURING INSTRUMENTS.*

BY SIR WILLIAM THOMSON, F.R.S.

(Continued from page 543, Vol. XVIII.)

The current-measuring instrument commonly called by the name of galvanometer, whether it be the sine galvanometer, the tangent galvanometer, or any of the different varieties of mirror galvanometers in use, is essentially magnetostatic. That is to say, it is an instrument in which a controlling magnet is used to balance the electro-magnetic force produced on a magnetised steel needle by a conductor or coil through which flows the current to be measured. In the sine galvanometer and tangent galvanometer, as originally used, and as still largely used for many important electrical measurements, the controlling magnet is the earth; but it is only in a locality far from dynamos and from wires carrying continuous† currents for electric lighting, that the terrestrial magnetic field suffices for a sine or a tangent galvanometer when any approach to accuracy is required; and thus in telegraph offices, workshops, and engine rooms it is generally desirable, if not absolutely necessary, to use a much stronger magnetic field than that of the earth for controlling the needle of a galvanometer; but whether the controlling magnet be the earth, or a steel magnet, its force is essentially inconstant, and therefore a magnetostatic galvanometer of any kind requires some means for determining from time to time the coefficient by which the absolute value of the current measured can be calculated from its indications, or a means of freshly adjusting the field to give any convenient absolute value to the readings on the scale of the instrument.

Sixteen or seventeen years ago I introduced a form of tangent galvanometer, which came to be called the "paddle-wheel galvanometer," from the appearance of the two coils being somewhat like the paddle-boxes of a paddle-steamer. In this instrument two coils adjustible to any desired equal distances on the two sides of the centre, act on a small needle, or group of small needles, hung by a single silk fibre, and carrying a pointer of about eight centimetres length, which shows deflections on a scale of unequal divisions proportional to the tangents of the deflections. Ordinarily the needle is acted upon by the terrestrial magnetic force alone; but sometimes in laboratory experiments a controlling magnet is placed either to augment or to diminish the controlling force on the needle. This instrument, though capable of considerable accuracy for absolute measurement in a locality free from local magnetic disturbance, was replaced by my graded galvanometers,‡ which have been found much more convenient for general purposes, and have been somewhat largely used since they were brought out five years ago. I have never, however, been satisfied with them, and I have been incessantly occupied in the attempt to produce an adjustible magnetostatic tangent galvanometer, which shall be both more convenient for ordinary use and more susceptible of high accuracy for scientific investigation than the graded galvanometers. I am not able this evening to show more than a half-finished attempt to realise this object, but I feel that I am now nearly touching it, and I hope at the commencement of next session to be able to place before you a working instrument of the magnetostatic class, which shall be thoroughly convenient for showing the number of lamps alight at any time in an ordinary dwelling house lighted by Edison-Swan lamps with direct current, and which shall also be available as a scientific measuring instrument to measure currents of from one to sixty amperes with a proportionate accuracy of one quarter per cent in the best part of its scale.

I have also made great efforts during the last six years to produce satisfactory constant standard instruments for measuring electric currents, and I have from time to time placed before you results in which the object was, to some degree, realised, but, as I have always told you, not satisfactorily. This time last year I placed before you and explained instruments depending on Faraday's discovery of the tendency of a globe, or cube, or short bar of soft iron, to move from places of weaker to places of stronger force in a magnetic field.* Two of those instruments which you saw, and which were then nearly completed, are again before you, and are now indicating the potential of the current by which we are lighted this evening. You see, when I increase the potential by reducing resistance, how the indicator shows—now an augmentation of 2½ per cent., which makes the lights considerably brighter—now again a diminution of one per cent.—and again the previous potential and the lights as they were. Since you first saw them these two instruments have been incessantly at work on the electric light wires in my house and laboratory, and have done good work all this time. I may say, in passing, they have allowed me to use much higher incandescence without risk to the lamps than would have been practicable without a trustworthy potential indicator, and personal, if not automatic, attention to regulate the potential according to its indications.

Though, however, they have so far been practically useful to myself, I am not satisfied with the instruments because they involve the use of soft iron, the retentiveness of which is always a serious trouble which I have only been able to keep within bounds, not completely to eliminate, by the use of the current reverser, which you see in connection with one of the instruments before you. I have, therefore, returned to the original discovery by Ampère of the mutual force between movable and fixed portions of an electric circuit, first utilised by Weber in his "Electro-dynamometer," to obtain a constant standard instrument for measuring electric currents without any of the trouble and residual inaccuracy entailed by the use of soft iron. After many trials I have succeeded in improving an electro dynamic balance, towards which I made a great many trials five years ago; and within the last three months I have succeeded in my laboratory in making accurate measurements of currents of from twenty milliamperes to 200 amperes by means of four instruments on the general plan of the rudimentary centi-ampere balance before you, in which a single movable coil is repelled and attracted upwards by two fixed coils, one below it and the other above it, and the total of the electro-magnetic force is balanced by a weight hung on a knife edge attached to the balance.† At the commencement of next session I hope to show you some of these instruments in a state fit for practical work. In the meantime I can only thank you for the patience with which you have listened to me this evening, and for the kindness with which now, as on previous occasions, you have allowed me to bring half-done work before you, and to tell you of what I hoped to do, but had not yet done, in the way of producing practically useful instruments.

* "On a Double Chain of Electrical Measuring Instruments to Measure Currents from the Millionth of a Milliampere to a Thousand Amperes, and to Measure Potentials up to Forty Thousand Volts." Paper read before the Philosophical Society of Glasgow, April 20th, 1887.

† The neighbourhood of a conductor carrying an alternate current for electric lighting, however strong, would not disturb the terrestrial magnetic field for a sine galvanometer or tangent galvanometer in its neighbourhood.

‡ Patent No. 5,668, of 1881 (26th December).

* Patent No. 11,106, 9th August, 1884.

† Patent No 2,028, 21st April, 1883.

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CORRESPONDENCE.

THEORY OF SECONDARY CELLS—ELECTRIC EQUIVALENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: No doubt my friend D. G. FitzGerald is fully able to defend his own position. I feel impelled, however, to make some remarks upon Mr. Swinburne's letter, page 562, because the subject is one which was familiar to me at a time, years ago, when it was outside ordinary electric knowledge, and, in fact, almost unknown to electricians generally. Mr. Swinburne accuses Mr. FitzGerald of mixing up the new chemical notation and the old calorific values of chemical affinity. He sets his own position down thus: "In old days, when water was H O, it was correct to say Andrews's value for Zn O is 42,408; but now that water is H_2 O, Andrews's value is 84,816." I submit that in this statement it is Mr. Swinburne who mixes things up. What we have to consider, is not the molecular constitution of each individual substance, and the calorific value of such molecules, involving a constantly-varying datum value, the whole question is the equivalence of chemical affinities and E.M.F.—the relation, that is, of calories and volts.

Mr. Swinburne does not attach importance to this, because, as he says, he holds "that the E M.F. of a cell cannot be measured by the heats of combination, and that the heats of combination are not measures of chemical affinity." Mr. Swinburne should not be blamed for refusing to adopt the nearly universal opinion of scientific electricians and chemists; but, unfortunately, he sets himself against the facts, and that is always an unfortunate and difficult position to hold.

I may here say that it may be difficult always to trace exactly the relation and make the figures balance; but this is because the values themselves are as yet only approximately known, being difficult to measure exactly; and that an important element of calculation is generally omitted, *i.e.*, the heat of solution + or − of the various substances, in the quantity of water, &c., present in each case. But how is it possible to get an exact datum? The value depends upon the relative values of the volt, ohm, and ampere. Will any electrician be good enough to tell us what those units mean? What is their value, and what is the true mechanical equivalent of a "volt-ampere-ohm-second?" Until we get rid of the absurdity of the "legal" ohm, &c., related to no actual thing or system, but only to the erroneously fixed length of a column of mercury, which no one ever made or ever will make, and come back to the true units, the decimal multiples of the absolute units, there will be nothing but confusion possible.

However, we have to value the relation of chemical affinity, *i.e.*, *calories*, to this undetermined and unstable balanced electric unit. To speak of expressing volts in calories is absurd. The one is mere pressure, the other is kinetic energy. The "volt-ampere-ohm-second" is energy, and can be expressed in calories, foot-pounds, or any other unit of work, and the relation of E.M.F. to calories depends upon the number of these volt-ampere-ohm-seconds expended in doing an equivalent of chemical work.

Now the new notation of chemistry, while it has greatly set aside the idea of equivalents in our calculations, is none the less based upon that idea. *Its basis is one atom of hydrogen*, and its molecules become bivalent, tri, hex, &c., just as they are in their constituent ions equivalent to 2, 3, 6 univalent or hydrogen atoms. This is so in chemistry, though often ignored; but we cannot ignore it in the electric relations which include only molecules capable of division into two ions. Therefore, Mr. FitzGerald is entirely right in using a fixed unitary value,

$$\frac{\text{Atomic weight}}{\text{Valency}} = \text{Electric equivalent},$$

which means basing the calorific values on the relation of one atom of hydrogen, not upon two because we write water as H_2 O.

In the present uncertainty of what the various electrical units mean, I have reckoned that under unit conditions one ampere current takes 97,808·5 seconds to effect one gramme equivalent of electrolysis, and that the energy corresponding to this effected by one volt and in one ohm is 23,287·7 calories. This of course represents the 23,000 calories of Prof. S. Thompson, and no doubt we shall know some day what the exact value is. At present I am only concerned to maintain that this value is the proper one to use always, and that we should reduce all molecular calorific values to the terms of the equivalent in grammes of each substance; that, therefore, it is confusing and erroneous to call the volt equivalent (what I first called the "equi-volt") sometimes 23,000, sometimes 46,000, or generally $23{,}000 \times n$, merely because the molecules may have valencies of $1 \times n$.—Yours, &c.,

JOHN T. SPRAGUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I imagine Mr. Swinburne would agree that heat of combination is principally *chemical* energy transformed, and that it is accordingly a true measure of chemical affinity if corrected for accessory causes, increasing or diminishing the heat due to that source. For instance, heat resulting from a liquid constituent combining as a solid, or *vice versâ*, will obviously have no counterpart either in chemical affinity or in volts, and must be discounted in the estimation. But I am unwilling to regard his bookkeeping as a calculation that errs in its principle and purpose. However, while Mr. Swinburne so particularly refrains from asserting that the E.M.F. is the measure of the chemical affinities, I unhesitatingly commit myself to this opinion, and would like to say that the E.M.F. *is* the chemical affinities, or the resultant of them.

I am surprised that the expression "electrolytic thread" did not find in Mr. Swinburne's mind an answering idea; and yet he asks me what I mean. If in accusing me of "hypotheses" he means mental conceptions of what takes place in nature, it is no crime to own them, while it is a serious defect to be without them. I know that I feel angry when I hear of "contact potential differences," and that I am only half appeased when the expression is explained to mean *don't-know-why* potential differences; but all this is quite consistent in me. I commend people who foster good mental conceptions, and the only case in which I object to hypotheses is when people set aside the explanation which Nature herself suggests, and invent an agency of their own which they impute to Nature, and so fill up the gap of mystery. However, as to the electrolytic threads or chains, Mr. Swinburne will find pictures of them in Sprague's "Electricity," second edition, p. 118, art. 150, and p. 359, art. 585; also in Dr. Ferguson's "Electricity" (edition 1886), on p. 113, and doubtless in many other books.

As regards the disputed question of crediting the sulphate of lead at the peroxide plate, the point rather is whether this action is really a part of the process of discharge and not a local and extraneous action merely accompanying it, like the formation of sulphate of zinc on the brass plate in the case suggested by Mr. FitzGerald. I feel assured, for reasons previously mentioned, that it does not belong *directly* to the process of discharge, though at the same time I dare not say that it is entirely independent and unconnected with it. In my first letter I contemplated the possibility of this action modifying the E.M.F. of the lead cell, and I will now show in what manner this may occur. It is not unlikely that the *actual* bond of affinity with O in Pb O, O is weaker in presence of the rival acid radicle of an $H_2 S O_4$, not itself forming part of any polarised chain from plate to plate, but exercising a side influence, and tending to reconstitute itself by supplying $S O_3$ to Pb O, with the result of $Pb S O_4 + H_2 O$. Accordingly, a lesser amount than otherwise would have to be debited for Pb O, O decomposed.

I am quite aware that I am here answerable for another of my "hypotheses," but it is one that I can justify by illustration. Gold forms no chloride in plain H, Cl, because the bond H, Cl is sufficiently stable not to be ruptured by affinity between the gold and the chlorine. But H Cl mixed as *aqua regia* does attack gold, because the oxidant nitric acid seduces the H, and the partnership H Cl is therefore more easily dissolved. Again, how is it that sodium sulphate can be electrolysed by

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an E.M.F. quite unequal to the force of combination Na_2, SO_4? How is the alliance $Na_2 SO_4$ sundered? The secondary action, which forms caustic soda so far as it is a *subsequent* process affords no explanation; I could not lift 4 cwt. from the ground because I had means to support it *afterwards*. The explanation is, I believe, that secondary action exists *as an effort* simultaneously with the primary or true electrolytic action, and the $\overline{OH}$ of the water of solution acts seductively, so as to diminish the force of the bond Na_2, SO_4, making the real amount to be debited in decomposing Na_2, SO_4

$$Na_2, SO_4 \text{ less } [2\,Na, OH \text{ less } 2\,H, OH]$$

or the sum of $Na_2, SO_4 + 2\,H, OH$, less $2\,Na, OH$.

On the whole, in reckoning the chemical affinities in the lead cell my feeling is that the amount which should be debited for PbO, O decomposed is something very small, while the assets have the benefit of the O combining with hydrogen in addition to Pb, SO_4. The looseness of the combination PbO, O in presence of acid, and the semi-detached condition of the second O, may be gauged by the property which lead peroxide possesses of decomposing HCl. Nature here shows us that the *unsatisfied* affinity of O in PbO_2 is stronger than that of the Cl, which it deprives of the hydrogen.—Yours, &c.

37, Burlington-road, W. E. ALDRED WILLIAMS.

LONG DISTANCE TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article on telephonic enterprise in this country, especially in London, you mention that the United Telephone Company are going to bestir themselves, and intend getting some one from America to re-organise the system here. In my opinion—but of course I may be wrong—the Americans will do the company no good. It is they who inaugurated the system here, and we have to a great extent worked on the American system ever since, especially in our construction, and it is in that where we have failed. I wish to point out that the electrician who has gained his experience in America is totally unfitted to carry out work in England. He has been trained in a climate which is exceptionally dry; he naturally ignores the necessity for insulation here, because in America Nature has made it an item of little consideration.

Our climate during the greater part of the year is exceptionally a damp one, and more than this, our atmosphere, especially in our large cities and manufacturing districts, is charged with carbon dust. It is this dirt on the surface of our insulators, made more or less conducting by the moisture of the atmosphere, which causes all our difficulties.

A film of wet carbon particles on the surface of the insulators causes low and intermittent insulation and consequent disturbances, which are in many cases falsely ascribed to induction.

Prof. Thompson some time ago said he thought that a good deal that was put down to induction was due to leakage. I have not heard him say much on the subject since; perhaps his investigations in telephonic instruments have drawn his attention from the importance of construction.

In our dirtiest districts every insulator is theoretically a minute microphone, and if it is, each insulator is a source of disturbance, more or less, in accordance with the amount of moisture in the atmosphere.

Why I think that every insulator that is covered with carbon is a minute microphone is from the fact that the surface of the insulators is coated with a film of wet carbon, and it is the wet carbon filament interposing by means of surface leakage between line and earth that is the source of trouble. In our climate the quality of the insulators has little or nothing to do with the actual dielectric resistance of the line, it is entirely a question of surface leakage.

To give you an instance of the state of the atmosphere affecting insulation, the late Messrs. Laws and Hockin, when in Sydney, New South Wales, tested a land-line the dielectric resistance of which was 1,500 megohms per mile; this high insulation was in no way due to superior construction, but simply to the dry, clean state of the atmosphere, and no surface leakage.

Here, in England, the Government engineers would be contented with 1·5 megohm per mile right through the year. We shall never make advances in long-distance telephony until we get proper insulation; and those who have worked in dry climates are apt to ignore this important necessity; they are accustomed not to think about it.

Mr. W. H. Preece has made some successful experiments on long-distance telephony; but when he experiments he is careful enough to go some distance from London, and to avoid the region of dirty insulators, consequently his experiments are more theoretical than practical. I should like him to carry out some experiments from the centre of London to the centre of Liverpool or Manchester, especially on a line that has been erected for some years.

There are some other experiments that might well be made. I have said that our climate is an exceptionally damp one for the greater part of the year; but between the months of February and May we generally have east winds; it is then that our climate is dry.

Has Mr. Preece, or any of the engineers interested in long-distance telephony, noticed if there is less disturbance or that better results are obtained when an east wind or a north-east wind is blowing than when a south-west wind is blowing?

It is possible to construct a land-line in England, notwithstanding our damp and dirty atmosphere, which could give a constant dielectric resistance of, say, 1,000 meghoms per mile, and if the United Telephone Company is going to undertake long-distance lines I would strongly advise it to pay some attention to the all-important question of insulation, otherwise its money will be spent in vain.—Yours, &c.,

H. C. DONOVAN.

Morden Wharf, East Greenwich, May 9th.

CARDEW'S VOLTMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Those of your readers who are users of the above instrument may be interested to hear that the very annoying oscillation of the index, due to air currents in the tube, may be entirely stopped by using the voltmeter in a horizontal position. As the weight of the working wire causes the deflections to be somewhat reduced, decalibration is necessary before using a voltmeter in the new position.

This simple remedy for a grave defect is due to Mr. G. S. Ram.—Yours, &c., SYDNEY EVERSHED.

P.S. Since writing the above I learn that Prof. Ayrton discovered the same remedy some twelve months since. I think that many others will join me in regretting that this useful knowledge has been so long buried in the professional bosom.

Westminster, 11th May, 1887.

VARNISHING INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am pleased to see by Mr. Shippey's letter in your issue of to-day that my note on varnishing incandescent lamps has excited so much interest as to have been "recopied into many scientific journals." This is an honour I did not expect.

With regard to Mr. Shippey's advocacy of coloured glass in preference to varnishing, allow me to make one or two remarks. In the first place, I did not advise the use of either one process or the other. There was a paragraph in *The Electrician* stating that Messrs. Siemens and Halske had adopted a system of varnishing, and having had some experience in the matter, I sent you some practical details as to the best mode of doing this.

If the question were asked, What is the *best* mode of obtaining the effect of a coloured lamp in incandescent work? I

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should say without hesitation that it is neither the one I described nor the one Mr. Shippey advocates; but I should say the *best* way to arrive at the required result would be to put the plain lamp into a coloured globe. The use of coloured glass in the original manufacture of the lamp, which Mr. Shippey so strongly advises, is open to the fatal objection that a lamp made with a coloured glass globe cannot be *tested photometrically*, and there are therefore no means of knowing whether it is running at the desired temperature.—Yours, &c.,

NELSON H. CHERRILL.

London, May 6, 1887.

ELECTRICAL PHENOMENA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me a short space in your paper to ask if any of your readers have observed the following phenomenon?

I have noticed a brush of light playing at irregular intervals between the strap and the extreme edge of the disc or fly-wheel of a dynamo.

Is this due to leakage; and, if so, why does it take place at this point and not where the strap is in contact with the pulley? The pulley and disc are in one piece, and there is no resin on the strap.

Or is it due to an E.M.F. generated in the disc as it revolves in the field of the magnets similar to a Barlow wheel?—Yours, &c.,

LEAKAGE.

A NEW METHOD OF REGULATION IN THREE-WIRE DISTRIBUTION.

In the usual method of distribution on the three-wire system the current furnished by the dynamo passes to the main and then through a group of lamps to a connecting wire, from which it passes through another group of lamps to the other or return main, and thence to the dynamo. Such a system ordinarily requires that the energy of current or number of lamps be equal for each multiple arc group—that is, that the groups be "balanced;" but where this is not the case, a compensation may be secured by the employment of resistances placed in branch circuit around the group containing the fewest lamps, or in which the smallest current is needed.

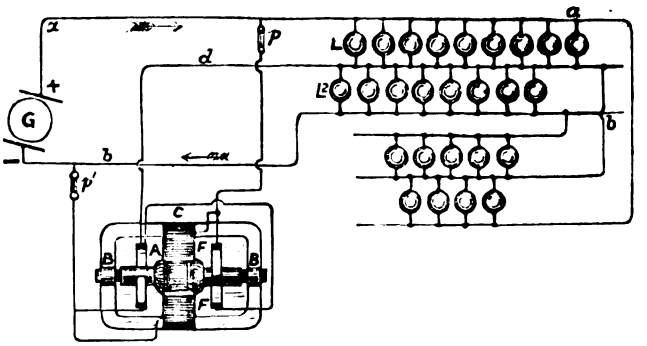
In a new arrangement designed by Prof. Elihu Thomson, to effect proper regulation of the current in each group of lamps, the compensation is rendered automatic, and at the same time a transfer of energy is made from the parts of the circuit where it would otherwise be in excess to those parts which require more. Prof. Thomson accomplishes this by combining with the mains of a multiple-arc series, or three-wire system, a converter which permits of the extinguishing of lamps in any multiple-arc group at will, relying upon the compensating apparatus to effect a proper balance.

The manner in which this is accomplished is illustrated in the accompanying diagram. In this G represents the generating dynamo, which maintains a fairly constant difference of potential between the mains *a* and *b*. The potential is sufficient to work two multiple-arc sets of lamps in series, as indicated at L L^2. The intermediate wire *d* unites the two sets.

Now, in operating such a system, so long as the number of lamps in L and L^2 be equal, or the current in both is alike, no difficulty will be experienced; but should a change take place, as by the extinction of a part of the lamps in the set L^2, an excess of current will traverse the remaining lamps of the set, increasing their brilliancy, and tending also to decrease the brilliancy of the lamps in group or set L.

Any attempt to adjust matters by changing the potential at the generator G is without avail. To overcome the difficulty Prof. Thomson attaches to the mains *a b d* what he terms a "compensator" or "converter," for current energy. One of his best arrangements is illustrated at C in the engraving. It consists of a sort of dynamo-generator or motor, or rather a combination of the two. The field-magnets F F are connected, one terminal to *a* and the other to *b*, as a shunt to the circuit or branch from *a* to *b* of rather high resistance, so as to demand but a very small fraction of the current.

The armature A is wound with a double winding or two separate and insulated sets of coils, which are, however, the counterparts of each other in electromotive energy. The armature-windings or sets of coils are each provided with a separate commutator and brushes, shown to the right and left of the armature A. The armature windings are made of quite low resistance, and of such length of wire that they will give, respectively, when revolving in the field F F at a high-speed, an electromotive force equal to that which normally exists between *a* and *d* and between *d* and *b*—*i.e.*, the voltage of the lamps used in L and L^2.



The connections are made as shown. If *a* be the positive wire of G, then *b* will be negative, and *d* nearly neutral, when the lamps in L and L^2 are equal in number. A wire is carried from *a*, through a fusible plug, *p*, to one of the brushes of the compensator C, which brush, when the armature A is revolved, will receive a counter electromotive force from the commutator segments, tending to oppose the potential of *a*. The opposite brush is connected to *d*. On the other side, as shown, and at the other commutator a brush is connected to *b* in like manner, so that when revolved the armature A will give a counter force to oppose the potential of *b*. The opposite (upper) brush is connected to *d*. The apparatus and circuits thus arranged will give the following results:—

Assuming the demand for current in L and L^2 the same, the potential between *a* and *d* will be equal to that existing between *d* and *b*. The armature A will receive current at both commutators, tending to short-circuit from *a* to *d* and from *d* to *b* through each set of coils on it. The result of current passing in A, if the brushes on the commutator be set on the neutral line, will be to drive A as a motor without load, and its speed of rotation will continually increase until the counter potentials developed in its coils almost neutralise the potentials between *a* and *d* and *d* and *b*, so that little current flows in A, and only enough to keep up the speed of A.

Now let some of the lamps L be cut off. The potential between *a* and *d* will at once rise, and that between *d* and *b* will fall, because the resistances are now no longer evenly distributed from *a* to *b*. As the resistances of the windings on A are quite low, more current will now pass from *a* to *d* through one winding of the compensator-armature A, and it will run faster than before. The device will now act as a generator to give current back to the circuit between *d* and *b* by the other winding, or, in other words, it becomes a motor-generator running by the higher potential to feed the main having the lower, and the action will occur with either winding on A, according as the higher potential exists between *a* and *d* or between *d* and *b*, the higher potential sending current through the motor-generator C and inducing current in the other armature-winding, which is fed out to raise the lower potential. It is essential that the resistances of the windings on A be so low as to be negligible.

As will be seen, under the conditions outlined above, the apparatus acts as a converter for turning or converting the electric energy or potential existing between one pair of mains into electric energy or potential between another pair, so as to effect an equalisation. As it is usually only necessary to provide for a partial extinction of lamps in either group, the compensator C is small compared to the generator G, and, furthermore, its effectiveness can be enhanced by constructing it to run at very high speeds, as it requires no belts, and there is no strain on its bearings.—*Electrical World.*

WESTERN AUSTRALIA.—Mr. William Helmich, the Postmaster-General and General Superintendent of Telegraphs in Western Australia, will retire on a pension at the end of June, after a long service of 40 years. The Secretary of State for the Colonies has conferred the appointment upon Mr. Charles F. Gahan, of the Colonial Civil Service, who will leave for King George's Sound by the "Chimborazo" on Saturday.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XVIII.

Volume XVIII. of "The Electrician," Price 10s. 6d., is now ready.

Also Cases for Binding, Price 2s.

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TENDERS FOR ELECTRIC LIGHTING.

Often as we have had bitterly to complain of hindrances thrown in the way of Electric Lighting by external hands, our complaints against the obstacles created from within have been hardly less frequent or less severe. It is bad enough to have to contend against powerful vested interests, against unscrupulous speculation, and against deep rooted prejudices; but these may be overcome by patience and time. What is even more vexatious and more difficult of correction is the short-sighted selfishness of electrical engineers themselves. We have on several occasions within the past two or three years pointed out the unwisdom of their opposing each other with a competitive zeal which would be appropriate only to an understocked market and a brisk demand. Further, we have urged upon them the urgent necessity for coming to a friendly understanding, and for combining with a view not merely of promoting legitimate business, but of preventing all attempts at business of the opposite description. To a certain extent our advice has been followed; but there is still room for a wider, closer, and more influential association than any that at present exists among electric lighting engineers, as is evident from such paragraphs as the one relating to the Southport tenders printed in our last week's issue—paragraphs, we are sorry to say, that are not of very rare occurrence.

We inserted the case above referred to as descriptive of "The Way Electric Light Business is Lost," and a reperusal of the facts will, we think, fully bear out our description. It seems that, for some reason which we do not pretend to understand, the manager of the Southport Gasworks recently invited and obtained tenders for lighting by electricity one of the streets of that town. Here was a case for extreme caution. We shall not be suspected of advising collusive tendering; but if ever there was an occasion for preliminary understanding among the intending applicants this was one. There should, for example, have been no conflict as to the amount of illumination required for the specified area; any serious divergence among them on this point would at once betray ignorance of their own profession, or a presumption of ignorance on the part of the person tendering—either of which might be fatal to the reputation of all the tenderers alike. Neither should there have been any great disparity in respect to the cost of an installation which appears to have presented no peculiar difficulties or problems outside the ordinary experience of everyday work. Still less should we expect to see any striking difference in the estimates for the annual maintenance of such a simple installation as this.

On none of these points, however, was there any sort of agreement among the fifteen firms who tendered for the job; on the contrary, their divergences were so great that it is evident that either they do not know their own business or that they suppose nobody else does. The space to be lighted, 14,000 yards in length and 30 broad, was specified, as was also the power (2,000 candles) of the lamps to be employed. In all else the tenderers were free—a good deal too free, apparently, for in every detail they differed so widely that it is impossible to avoid the conclusion that some at least of the offers were made not for business but for advertisement. We have not the whole particulars before us; but, broadly, the number of lamps estimated in the lowest tender was six, whilst in the highest it was fifty, the other estimates ranging indiscriminately between these two extremes. As regards the cost of the installation, the estimates varied from £695 to £3,625—a difference great enough in all conscience for so small an undertaking, but not nearly so great as it ought to be considering the diversity of estimate in regard to the number of lamps. In respect to annual maintenance the proportion is more consistent, being £72 on the one hand and £663 on the other; but on that very account the whole calculation is rendered transparently untrustworthy.

It is easy to be seen that the lower estimates have been accidentally or intentionally miscalculated, and that the work could in no circumstances be done for the money. But this is not a view of the case we can expect outsiders to take of such incidents, certainly not the managers of gasworks. Of course the scheme was abandoned altogether, and the fifteen tenderers have only succeeded in bringing ridicule on their profession, and doing serious injury to electric lighting business generally. The Southport Gasworks manager probably drew the natural inference that either the lowest was a bogus tender or that the highest was a fraud; and that most of the remaining thirteen tenders were more or less of the same character. Probably, also, he came to the conclusion that a profession which varied so greatly in its estimate of things was not quite to be trusted yet awhile. No one can be surprised if the people of Southport do not renew their overtures to the electric light for some years to come. These incidents are the more deplorable, because they often provide the local authorities with precisely the excuse they desire for declining to accede to the wishes of the inhabitants in respect to electric lighting. If this kind of indiscriminate

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and reckless tendering goes on much longer, all that any section of a local board opposed to the electric light need do to insure its rejection will be to agree to submitting an installation to public competition. The tenders will duly arrive, and if they resemble in any way those upon which we have been commenting, the result is certain. Electrical engineers have the remedy in their own hands, and we invite them to lose no time in taking the matter seriously into their consideration.

AUSTRALASIAN TELEGRAPHY.

We give below the final proposals made by the Eastern Extension Telegraph Company, submitted by Mr. J. Pender, the chairman of the company, to the recent Colonial Conference. It will be seen that the concessions offered by the company are of a very substantial nature; the existing tariff would be reduced to less than one-half. We have again and again pointed out that the telegraph companies could not possibly undertake even the temporary loss of income due to so great a lowering of the tariff, and naturally they ask that the risk should be minimised by a guarantee from the colonies interested to the extent of three-fourths of the existing revenue, the companies themselves participating in the risk, and therefore in the guarantee, to the extent of one-fourth of the existing revenue. This proposal shows that the companies are desirous of meeting the demands made upon them for a cheaper tariff, and the management goes as far as, even if not a little farther than, is consistent with its duties to the shareholders. It must be recognised that there is not, never has been, nor ever will be, a time when the claims of the shareholders in a private company can be ignored, and in considering a question of this magnitude that question must never be forgotten. The directors of the companies working the cable system to our eastern colonies have always been conspicuous for their efforts to make the system as perfect as possible, and little inconvenience has ever arisen from interruption of traffic. Their offer is now before the public, who will, we venture to predict, agree with us in regarding it as a businesslike and liberal concession.

Proposition of the Eastern Extension Company to the Australasian Colonies, subject to the Approval of all the Interested Administrations.

That they should guarantee to the companies carrying Australasian telegrams, viz.:—The Eastern, Indo-European, and Eastern Extension Companies, their annual revenue based on the average of the three years ended 1886, for 13 years, the unexpired term of the duplicate Cable Subsidy, and make the through tariff 4s. per word. At the end of the term the question would have to be reconsidered with a view to a fresh arrangement.

Average annual traffic receipts of the three companies from Australasian telegrams, exclusive of existing subsidies, viz.:—

Eastern	£52,300	
Indo-European	7,700	
Eastern Extension	125,000	
	£185,000	
Estimated revenue at a 4s. tariff between Europe and Adelaide, based on present traffic, and assuming that South Australia accept a transit rate of 5d. per word:—*(See table below)*	80,000	
		£105,000
The companies will take the whole risk of any falling off of traffic receipts below £80,000, and also accept one-fourth of the guarantee risk, viz.:—	26,250	
Leaving as the *maximum liability* of the colonies if no increase of traffic takes place	78,750	
		£105,000

If the traffic receipts increased by:—

25 per cent. the colonies would have to make up	£63,750
50 ,, ,, ,, ,, ,,	48,750
75 ,, ,, ,, ,, ,,	33,750
100 ,, ,, ,, ,, ,,	18,750

distributed as follows:—

GUARANTEE.

Colony.	Population based on 1885 Statistics.†	Amount to be made up, exclusive of Subsidies, if Traffic increased by 25%.	50%.	75%.	100%.
Victoria	991,869	£19,029	£14,552	£10,074	£5,597
New South Wales.	957,914	13,379	14,055	9,730	5,406
South Australia..	313,423	6,012	4,597	3,183	1,768
Western Australia	35,186	676	517	358	199
New Zealand	575,226	11,035	8,439	5,842	3,246
Queensland	315,489	6,050	4,626	3,203	1,779
Tasmania	133,791	2,569	1,964	1,760	755
Total	3,322,898	£63,750	£48,750	£33,750	£18,750

†These are the most recent statistics in the company's possession, but the latest ascertained populations would, of course, form the basis of the calculations.

If the subsidies were pooled and distributed over all the colonies according to population, result would be as follows:—

SUBSIDIES.

Colony.	Existing contributions in respect of Duplicate Cable on 1881 census.	Contributions in respect of New Zealand and Tasmanian Cables.	Contributions if subsidies spread over all colonies on basis of population, '85.
Victoria	£14,479	—	£13,164
New South Wales..	12,617	2,500	12,714
South Australia	4,805	—	4,159
Western Australia.	499	—	467
New Zealand	—	5,000	7,634
Queensland	—	—	4,185
Tasmania	—	4,200	1,777
	£32,400	£11,700	£44,100

The following table shows the contribution of each colony if subsidies and guarantee combined and distributed over all colonies, according to population on basis of 1885 statistics:—

SUBSIDIES AND GUARANTEE COMBINED.

	25%	50%	75%	100%
Victoria	£32,193	£27,716	£23,239	£18,760
New South Wales	31,093	26,769	22,444	18,121
South Australia	10,170	8,756	7,341	5,926
Western Australia	1,143	984	825	666
New Zealand	18,669	16,072	13,476	10,879
Queensland	10,235	8,811	7,388	5,965
Tasmania	4,347	3,742	3,137	2,533
	£107,850	£92,850	£77.850	£62,850

PRESENT TRAFFIC SHOWING PROPORTIONS AT 4s. TARIFF.

Class of Traffic.	Number of words.	Companies' proportion of 4s. Tariff.	Outpayments.	Total Tariff.
		s. d.	s. d.	s. d.
Ordinary	489,000	2 5½	1 6½	4 0
Government	41,000	2 5	1 6½	3 11½
Press	70,000	1 11	0 9	2 8
Local (including India)	54,000	3 0	1 0	4 0
Total	654,000			

The above proposition is based upon a continuous service and freedom from competition. In the event of the communication being totally interrupted, the guarantee to continue for a period of one month.

Since the Australian cables were duplicated in 1880 the service with Australia has been interrupted for only 26 days, or on an average of less than four days annually.

AN EIGHT-LIGHT DYNAMO.

BY GEO. M. HOPKINS.

Unfortunately for the tyro in electrical matters, no rule or set of rules exists in the literature of dynamo-electric machinery which would enable him, with entire confidence of success, to plan a new form of dynamo, or even to attempt to construct any one of the well known forms. The available information generally fails in some minor details, thus, in some degree, obscuring the whole subject, and awakening doubts as to the best course to pursue. One might follow such information as closely as possible, and proceed so far as to make an operative machine, and yet it might happen that no current could be evoked from it, simply for the want of specific knowledge as to how to secure the first increment of magnetism necessary for starting the inductive process. * * *

It is not the purpose of the present paper to treat on dynamos in general, but to give, as fully as possible, specific information as to the construction of a small dynamo-electric machine capable of supplying a current for eight 16 candle-power incandescent 50-volt

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lamps, or a larger number of smaller incandescent lamps of suitable resistance, or an arc lamp of ordinary power. The armature speed is 2,200 revolutions per minute, and the machine running normally requires one horse-power to drive it. The machine weighs 130lb, and occupies a floor space of 8in. by 18in. The dimensions of the machine are tabulated below :—

Height of field-magnet	13	inches.
Length of field-magnet waist	6⅞	,,
Width of field-magnet waist	5⅜	,,
Thickness of field-magnet waist	1⅝	,,
Depth of polar extremities from waist to base	4½	,,
Width of polar extremities	6¾	,,
Thickness of polar extremities	3	,,
Diameter of bore of polar extremities	3⅝	,,
Thickness of yoke	1⅞	,,
Diameter of bolts passing through the yoke	⅝	,,
Length of armature shaft	18	,,
Diameter of armature shaft	⅝	,,
Diameter of armature shaft bearings	¾	,,
Length of parallel faces of armature	6¾	,,
Diameter of iron rings of armature core, outside	3	,,
Diameter of rings of armature core, inside	1⅞	,,
Thickness of rings	1/32	,,
Number of iron rings on armature core	39	
Diameter of wooden armature core	1⅞	,,
Length of wooden armature	6⅝	,,
Length of armature core	6⅝	,,
Number of divisions of the armature core	24	
Number of divisions of the commutator cylinder	24	
Length of commutator cylinder	2	,,
Width of brushes	⅛	,,
Size of wire on armature, No. 20 Am. W. G.	0·027	in diam.
Length (approximate) of wire in each armature coil*	25	feet.
Number of convolutions in each layer	8	
Number of convolutions in each coil	16	
Number of layers in each coil	2	
Number of coils in each space of the armature	2	
External diameter of armature	3⅜	inches.
Weight of wire on armature	2¼	pounds.
Diameter of pulley on armature shaft	3½	inches.
Width of pulley on armature shaft	2½	,,
Width of driving belt	2	,,
Size of wire on field-magnet, No. 18 Am. W. G.	0·033	in diam.
Number of parallel wires on each leg of field-magnet	4	
Number of layers of wire on each leg of field-magnet	8	
Number of layers for each wire	2	
Weight of wire on field-magnet	17	pounds.

The field-magnet is made of two like parts of soft, grey cast iron, joined at the centre of the yoke, and bound together by two bolts, as shown in Fig 1. The adjoining surfaces of the yoke are accu-

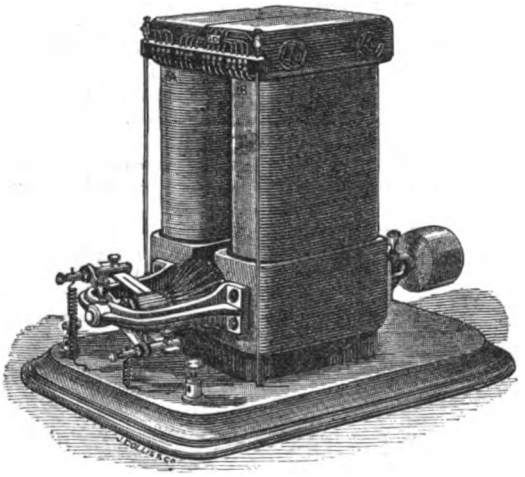

Fig. 1.—Eight-light Dynamo.

rately faced, so that when clamped together the connected halves of the magnet will be practically the same as if made integrally.

The bore of the polar extremities of the magnet is 3⅝in. in diameter, and the sides of the magnet around the bore are faced in the lathe to form a true support for the bronze yokes supporting the ends of the armature shaft. These yokes are bored to receive the armature shaft, and faced in the lathe upon the surfaces abutting against the sides of the magnet. The yokes are secured in their places on the magnet with their centres coincident with the axis of the bore of the magnet.

The armature shaft is fitted so as to revolve freely on its bearings, and there is a clearance between the periphery of the armature and the magnet of about ⅛in. Upon the portion of the armature shaft lying between the poles of the field-magnet is placed the cylinder, of seasoned hard wood of the size above given. Upon this wooden cylinder are placed the thirty-nine iron rings or washers, with intervening paper rings of the same size and about 1/32in. thick. The iron rings are drilled at diametrically opposite points to receive the brass rods by which the entire series is held together. The arrangement of the parts of the core of the armature is shown in Fig. 2, in which some of the iron rings have been separated, to more clearly illustrate the construction.

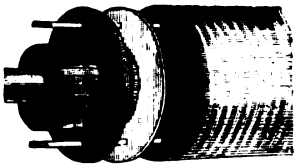

Fig. 2.—Parts of Armature Core.

The series of iron rings is secured to the wooden cylinder and the shaft by two pins passing through the rings, the wooden cylinder, and the shaft. The edges of the end rings are rounded, to prevent them from cutting the insulation of the wires. In two of the rings, at each end of the armature core, are formed 24 equidistant radial slots, *b* (Fig. 3), one-eighth inch deep and one-sixteenth inch wide. The armature core thus formed is covered over its entire surface with adhesive tape, such as is commonly used by wire men for covering joints in conductors. The tape is wound spirally on the periphery of the core, and is arranged radially on the end of the core. It is also wound spirally upon the shaft one and three-eighths inches in each direction from the ends of the armature core. Into the radial slots *b* are driven small wedges, *a*, of hard rubber, which are allowed to project three-sixteenths of an inch beyond the periphery of the core.

The winding of the armature is most readily done in a lathe, as shown in Fig. 3. The armature shaft with a dog attached is supported between the centres of the lathe, with dog in engagement with the face plate. A spool of No. 20 wire* is supported in a convenient position at the back of the lathe, and after bending the end of the wire around one of the wedges, leaving about four inches projecting beyond the wedge, the winding is begun. The wire is carried by one hand along the surface of the armature core and through the space between two wedges at the opposite end of the core, corresponding with the space in which the coil was started. The other hand grasps the face plate of the lathe, and as the wire is carried across the end of the armature core, the face plate is dexterously turned through a half revolution, bringing the opposite side of the core uppermost. The wire is then laid between the two

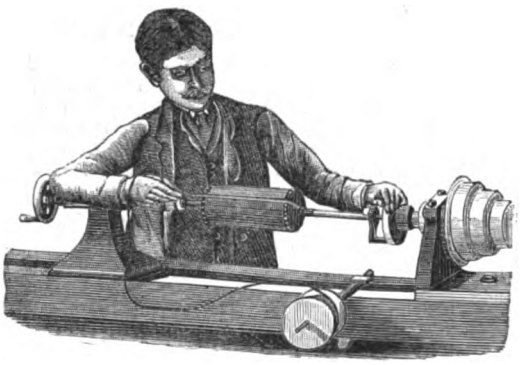

Fig. 3.—Method of Winding.

pairs of wedges diametrically opposite those embracing the wire on the other side of the armature. The wire is carried across the commutator end of the armature core, and the armature is returned to the position of starting by returning the face plate to its first position and the wire is laid alongside of the portion first laid on. The wire is carried lengthwise around the armature in this manner until eight parallel convolutions have been laid on. This layer of wire will extend across the space between two of the wedges. In Fig. 4 the inner layer B is represented as being raised from the core, to more clearly show the position of the wire on the armature, and the inner and outer coils are widely separated ; but it will of course be understood that these

* This quantity varies a few inches with the different coils.

* The wire used is the best cotton covered magnet wire.

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wires are to lie as closely as possible to the core in the working machine. The beginning or inner terminal E of the coil B is represented in black. In practice this end of the wire is always coated with coloured varnish as soon as the coil is complete, and before the two ends of the coil are twisted together, as they always are temporarily, for convenience in winding, so that there cannot be a mistake as to which are the inner and outer ends of each coil.

After winding the inner layer of the first coil, the winding is continued, forming the outer layer D on top of the inner layer, by winding in the same direction, but returning by the successive coils of the second layer towards the point of starting. When the outer layer is complete the wire is cut, leaving a projecting end about 4in. long. The coloured or inner end of the wire is now twisted with the outer or uncoloured end. In this manner, the first coil is placed in the spaces 1, 1, of the armature. It will be observed by reference to Figs. 4 and 5 that the two halves of each coil are arranged across the end of the armature on opposite sides of the shaft. This secures a compact end and a minimum amount of dead wire.

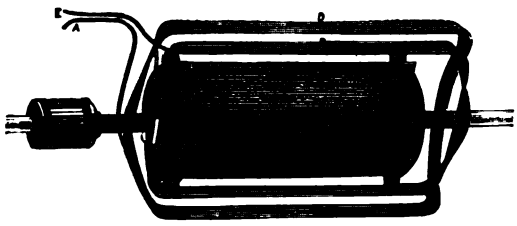

FIG. 4.—First Coil on Armature.

After placing one coil in spaces 1, 1, in the manner described, spaces 2, 2, are filled in the same way, then 3, 3, and so on, until twelve coils are wound upon the core. These coils half fill all of the pairs of spaces 1, 1, 2, 2, 3, 3, &c., to 12, 12, with terminals, A, E, projecting from each space around one-half of the periphery of the commutator end of the armature, the end of the armature presenting an appearance which would be indicated by Fig. 5, if the coils G F were omitted. When the armature is half filled, the winding is continued in exactly the same manner and in the same

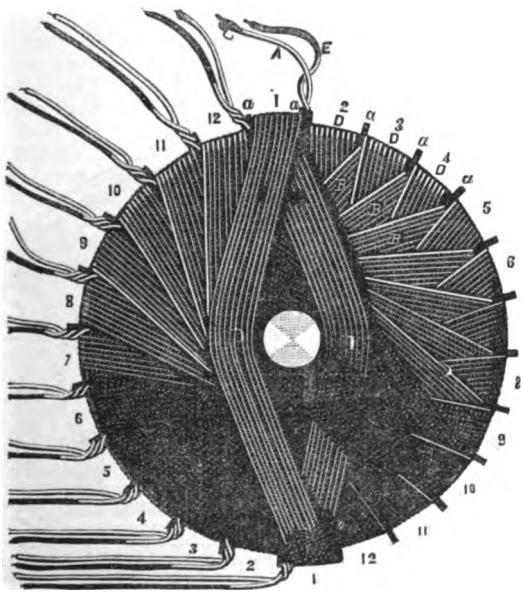

FIG. 5.—Starting the Outer Series of Coils.

direction as before, forming a coil of two layers, F, G, in spaces 1, 1, on top of the first coil B, D, leaving projecting terminals, as in the case of the first series of coils. Then a similar coil is formed on top of the coil in spaces 2, 2, and so on, until each pair of spaces contains two coils, one superposed on the other, every coil being formed of two layers of wire, with eight strands in each layer.

It is advisable, before winding the outer series of coils, to bind the inner series close to the core by a winding of stout linen thread at three equidistant points in the length of the armature. As a guard against the possibility of short-circuiting, the terminals of each coil, where they are in contact with each other or with other portions of the wire, should be provided with an extra wrapping of cotton. The armature thus constructed is known as the Siemens or Hefner-Alteneck armature.

There is another method of constructing the core of the armature which yields good results, but is in some respects inferior to the one described. The armature shaft carries a spool of wood or other non-magnetic material, upon which is wound varnished soft iron wire—the wire being used instead of the iron rings. The commutator cylinder, the method of connecting the terminals of the armature coils with the bars of the commutator cylinder, the brushes, the field-magnet winding, the connections, and other features, remain to be described.—*Scientific American.*

HISTORICAL NOTES ON THE RING DYNAMO WITH INTERIOR MAGNETS.

[The following information has been supplied to us by the London representatives of the firm of Siemens Bros. and Co.]

It not unfrequently happens that while some invention or discovery is being elaborated by the original discoverers, if a short note has been published in a technical journal of the principle involved, others rush at once into print with a description of a similar design, so that when the final work of the originators is fully developed and published, it would appear as though they were the plagiarists, when in point of fact the contrary is the truth. A case in point is the ring dynamo with interior magnets. A description of a dynamo of this type, as manufactured by Messrs. Ganz and Co., of Buda-Pesth, has lately appeared in *Industries*, and any person reading the article would naturally be led to the belief that this firm were the originators of this particular type of dynamo.

Shortly described, the ring dynamo consists of a fixed central electro-magnet, with four limbs at right angles to each other; through the centre of this electro-magnet passes the axle of the external Pacinotti ring, which revolves outside the fixed central magnet. The outside ring is of considerable diameter, and as it entirely surrounds the magnetic field the lines of force must necessarily pass through it. The first continuous-current dynamo of this type with a Pacinotti ring, and with magnets inside the ring only, in the shape of a double T, formed one of the exhibits of Messrs. Siemens and Halske at the Paris Exhibition in 1881. Since that time they have been occupied in developing and perfecting this form of dynamo, and on the 22nd October, 1886, an application was made by them to the German Patent Office. The specification describes the practically completed form of the the ring dynamo with an interior multipolar electro-magnet. The communication with a detailed description and drawings was made public to everyone in the usual way on the 14th January of this year in the *Journal* of the Patent Office. Moreover, in the same month of January the detailed drawings of four large dynamos of this type were submitted by Messrs. Siemens and Halske with their tender for the electric lighting of the Frankfort Central Railway Station, and on the basis of this tender, the contract for the work was awarded to them.

At the meeting of the Berlin Electro-Technical Society, on the 29th March last, a paper was read by Mr. von Hefner-Alteneck on the "Ring Dynamo with Interior Magnets," which paper was subsequently printed in the April number of the *Journal* of the Society. No other publication had been made by Messrs. Siemens and Halske up to that time.

In the number of the *Zeitschrift für Elektrotechnik* (Vienna), of the 1st April, and in that of the *Centralblatt für Elektrotechnik* of the same date, the firm of Messrs. Ganz and Co., of Buda-Pesth, come forward with a dynamo, which, if different in details, is yet in design similar to the ring dynamo, and they state that in 1884 the question occurred to them to construct a dynamo capable of giving the greatest possible output, whilst having the least possible weight.

The *Centralblatt* accompanied this article by a foot note, to which it is desirable to give the widest possible circulation, while reproducing exactly the punctuation:—"Editorial note. The firm of Siemens and Halske is at present engaged in bringing out the same construction!!"

Messrs. Ganz and Co. maintain in the above-mentioned article that their dynamo is the offspring of the alternate current machine of the Zipernowski type, which they have constructed. It might equally well be said that the much older Gramme alternate current machine, which has a Pacinotti ring outside, and electro-magnets inside, is a much nearer parent to their new dynamo. Moreover, the Zipernowski machine, constructed in 1882 or 1883, had a striking family resemblance to the well-known Siemens alternate current machine, as it was modified in the German patent of the 3rd April, 1878, and as it was constructed by Messrs. Siemens and Halske prior to Messrs. Ganz and Co., and shown at the Vienna Exhibition in 1883.

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lamps, or a larger number of smaller incandescent lamps of suitable resistance, or an arc lamp of ordinary power. The armature speed is 2,200 revolutions per minute, and the machine running normally requires one horse-power to drive it. The machine weighs 130lb, and occupies a floor space of 8in. by 18in. The dimensions of the machine are tabulated below :—

Height of field-magnet	13	inches.
Length of field-magnet waist	6$\frac{7}{8}$	,,
Width of field-magnet waist	5$\frac{3}{8}$	,,
Thickness of field-magnet waist	1$\frac{5}{8}$	,,
Depth of polar extremities from waist to base	4$\frac{1}{2}$	,,
Width of polar extremities	6$\frac{3}{4}$	,,
Thickness of polar extremities	3	,,
Diameter of bore of polar extremities	3$\frac{3}{8}$	,,
Thickness of yoke	1$\frac{7}{8}$	,,
Diameter of bolts passing through the yoke	$\frac{5}{8}$	,,
Length of armature shaft	18	,,
Diameter of armature shaft	$\frac{5}{8}$	,,
Diameter of armature shaft bearings	$\frac{1}{2}$	,,
Length of parallel faces of armature	6$\frac{1}{4}$	,,
Diameter of iron rings of armature core, outside	3	,,
Diameter of rings of armature core, inside	1$\frac{7}{8}$	,,
Thickness of rings	$\frac{1}{16}$	,,
Number of iron rings on armature core	39	
Diameter of wooden armature core	1$\frac{7}{8}$	,,
Length of wooden armature	6$\frac{5}{8}$	,,
Length of armature core	6$\frac{3}{8}$	,,
Number of divisions of the armature core	24	
Number of divisions of the commutator cylinder	24	
Length of commutator cylinder	2	,,
Width of brushes	$\frac{13}{16}$	,,
Size of wire on armature, No. 20 Am. W. G.	0·027	in diam.
Length (approximate) of wire in each armature coil*	25	feet.
Number of convolutions in each layer	8	
Number of convolutions in each coil	16	
Number of layers in each coil	2	
Number of coils in each space of the armature	2	
External diameter of armature	3$\frac{3}{8}$	inches.
Weight of wire on armature	2$\frac{1}{2}$	pounds.
Diameter of pulley on armature shaft	3$\frac{1}{2}$	inches.
Width of pulley on armature shaft	2$\frac{1}{2}$	,,
Width of driving belt	2	,,
Size of wire on field-magnet, No. 18 Am. W. G.	0·033	in diam.
Number of parallel wires on each leg of field-magnet	4	
Number of layers of wire on each leg of field-magnet	8	
Number of layers for each wire	2	
Weight of wire on field-magnet	17	pounds.

The field-magnet is made of two like parts of soft, grey cast iron, joined at the centre of the yoke, and bound together by two bolts, as shown in Fig 1. The adjoining surfaces of the yoke are accurately faced, so that when clamped together the connected halves of the magnet will be practically the same as if made integrally.

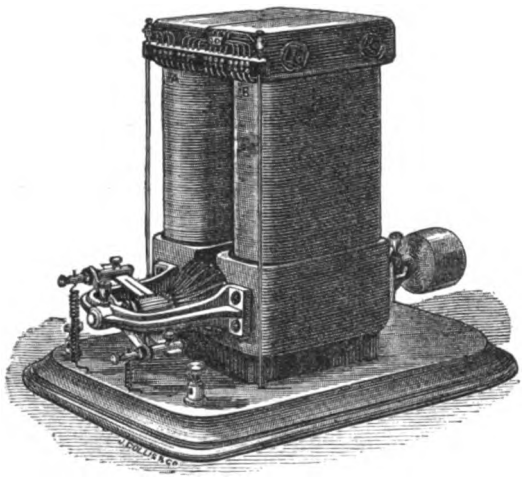

FIG. 1.—Eight-light Dynamo.

The bore of the polar extremities of the magnet is 3$\frac{3}{8}$in. in diameter, and the sides of the magnet around the bore are faced in the lathe to form a true support for the bronze yokes supporting the ends of the armature shaft. These yokes are bored to receive the armature shaft, and faced in the lathe upon the surfaces abutting against the sides of the magnet. The yokes are secured in their places on the magnet with their centres coincident with the axis of the bore of the magnet.

The armature shaft is fitted so as to revolve freely on its bearings, and there is a clearance between the periphery of the armature and the magnet of about $\frac{1}{8}$in. Upon the portion of the armature shaft lying between the poles of the field-magnet is placed the cylinder, of seasoned hard wood of the size above given. Upon this wooden cylinder are placed the thirty-nine iron rings or washers, with intervening paper rings of the same size and about $\frac{1}{32}$in. thick. The iron rings are drilled at diametrically opposite points to receive the brass rods by which the entire series is held together. The arrangement of the parts of the core of the armature is shown in Fig. 2, in which some of the iron rings have been separated, to more clearly illustrate the construction.

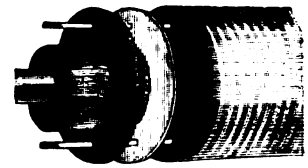

FIG. 2.—Parts of Armature Core.

The series of iron rings is secured to the wooden cylinder and the shaft by two pins passing through the rings, the wooden cylinder, and the shaft. The edges of the end rings are rounded, to prevent them from cutting the insulation of the wires. In two of the rings, at each end of the armature core, are formed 24 equidistant radial slots, *b* (Fig. 3), one-eighth inch deep and one-sixteenth inch wide. The armature core thus formed is covered over its entire surface with adhesive tape, such as is commonly used by wire men for covering joints in conductors. The tape is wound spirally on the periphery of the core, and is arranged radially on the end of the core. It is also wound spirally upon the shaft one and three-eighths inches in each direction from the ends of the armature core. Into the radial slots *b* are driven small wedges, *a*, of hard rubber, which are allowed to project three-sixteenths of an inch beyond the periphery of the core.

The winding of the armature is most readily done in a lathe, as shown in Fig. 3. The armature shaft with a dog attached is supported between the centres of the lathe, with dog in engagement with the face plate. A spool of No. 20 wire* is supported in a convenient position at the back of the lathe, and after bending the end of the wire around one of the wedges, leaving about four inches projecting beyond the wedge, the winding is begun. The wire is carried by one hand along the surface of the armature core and through the space between two wedges at the opposite end of the core, corresponding with the space in which the coil was started. The other hand grasps the face plate of the lathe, and as the wire is carried across the end of the armature core, the face plate is dexterously turned through a half revolution, bringing the opposite side of the core uppermost. The wire is then laid between the two pairs of wedges diametrically opposite those embracing the wire on the other side of the armature. The wire is carried across the commutator end of the armature core, and the armature is returned to the position of starting by returning the face plate to its first position and the wire is laid alongside of the portion first laid on. The wire is carried lengthwise around the armature in this manner until eight parallel convolutions have been laid on. This layer of wire will extend across the space between two of the wedges. In Fig. 4 the inner layer B is represented as being raised from the core, to more clearly show the position of the wire on the armature, and the inner and outer coils are widely separated ; but it will of course be understood that these

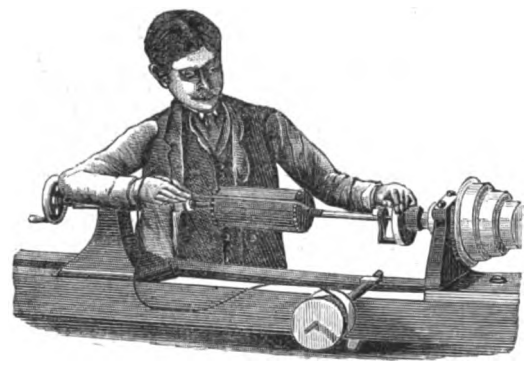

FIG. 3.—Method of Winding.

* This quantity varies a few inches with the different coils.

* The wire used is the best cotton covered magnet wire.

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wires are to lie as closely as possible to the core in the working machine. The beginning or inner terminal E of the coil B is represented in black. In practice this end of the wire is always coated with coloured varnish as soon as the coil is complete, and before the two ends of the coil are twisted together, as they always are temporarily, for convenience in winding, so that there cannot be a mistake as to which are the inner and outer ends of each coil.

After winding the inner layer of the first coil, the winding is continued, forming the outer layer D on top of the inner layer, by winding in the same direction, but returning by the successive coils of the second layer towards the point of starting. When the outer layer is complete the wire is cut, leaving a projecting end about 4in. long. The coloured or inner end of the wire is now twisted with the outer or uncoloured end. In this manner, the first coil is placed in the spaces 1, 1, of the armature. It will be observed by reference to Figs. 4 and 5 that the two halves of each coil are arranged across the end of the armature on opposite sides of the shaft. This secures a compact end and a minimum amount of dead wire.

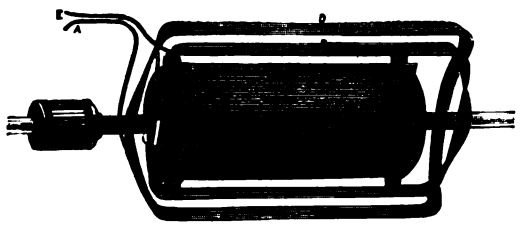

FIG. 4.—First Coil on Armature.

After placing one coil in spaces 1, 1, in the manner described, spaces 2, 2, are filled in the same way, then 3, 3, and so on, until twelve coils are wound upon the core. These coils half fill all of the pairs of spaces 1, 1, 2, 2, 3, 3, &c., to 12, 12, with terminals, A, E, projecting from each space around one-half of the periphery of the commutator end of the armature, the end of the armature presenting an appearance which would be indicated by Fig. 5, if the coils G F were omitted. When the armature is half filled, the winding is continued in exactly the same manner and in the same

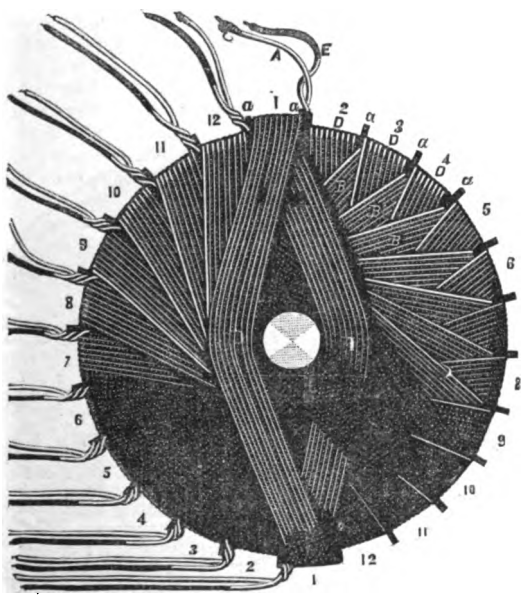

FIG. 5.—Starting the Outer Series of Coils.

direction as before, forming a coil of two layers, F, G, in spaces 1, 1, on top of the first coil B, D, leaving projecting terminals, as in the case of the first series of coils. Then a similar coil is formed on top of the coil in spaces 2, 2, and so on, until each pair of spaces contains two coils, one superposed on the other, every coil being formed of two layers of wire, with eight strands in each layer.

It is advisable, before winding the outer series of coils, to bind the inner series close to the core by a winding of stout linen thread at three equidistant points in the length of the armature. As a guard against the possibility of short-circuiting, the terminals of each coil, where they are in contact with each other or with other portions of the wire, should be provided with an extra wrapping of cotton. The armature thus constructed is known as the Siemens or Hefner-Alteneck armature.

There is another method of constructing the core of the armature which yields good results, but is in some respects inferior to the one described. The armature shaft carries a spool of wood or other non-magnetic material, upon which is wound varnished soft iron wire—the wire being used instead of the iron rings. The commutator cylinder, the method of connecting the terminals of the armature coils with the bars of the commutator cylinder, the brushes, the field-magnet winding, the connections, and other features, remain to be described.—*Scientific American.*

HISTORICAL NOTES ON THE RING DYNAMO WITH INTERIOR MAGNETS.

[The following information has been supplied to us by the London representatives of the firm of Siemens Bros. and Co.]

It not unfrequently happens that while some invention or discovery is being elaborated by the original discoverers, if a short note has been published in a technical journal of the principle involved, others rush at once into print with a description of a similar design, so that when the final work of the originators is fully developed and published, it would appear as though they were the plagiarists, when in point of fact the contrary is the truth. A case in point is the ring dynamo with interior magnets. A description of a dynamo of this type, as manufactured by Messrs. Ganz and Co., of Buda-Pesth, has lately appeared in *Industries*, and any person reading the article would naturally be led to the belief that this firm were the originators of this particular type of dynamo.

Shortly described, the ring dynamo consists of a fixed central electro-magnet, with four limbs at right angles to each other; through the centre of this electro-magnet passes the axle of the external Pacinotti ring, which revolves outside the fixed central magnet. The outside ring is of considerable diameter, and as it entirely surrounds the magnetic field the lines of force must necessarily pass through it. The first continuous-current dynamo of this type with a Pacinotti ring, and with magnets inside the ring only, in the shape of a double T, formed one of the exhibits of Messrs. Siemens and Halske at the Paris Exhibition in 1881. Since that time they have been occupied in developing and perfecting this form of dynamo, and on the 22nd October, 1886, an application was made by them to the German Patent Office. The specification describes the practically completed form of the the ring dynamo with an interior multipolar electro-magnet. The communication with a detailed description and drawings was made public to everyone in the usual way on the 14th January of this year in the *Journal* of the Patent Office. Moreover, in the same month of January the detailed drawings of four large dynamos of this type were submitted by Messrs. Siemens and Halske with their tender for the electric lighting of the Frankfort Central Railway Station, and on the basis of this tender, the contract for the work was awarded to them.

At the meeting of the Berlin Electro-Technical Society, on the 29th March last, a paper was read by Mr. von Hefner-Alteneck on the "Ring Dynamo with Interior Magnets," which paper was subsequently printed in the April number of the *Journal* of the Society. No other publication had been made by Messrs. Siemens and Halske up to that time.

In the number of the *Zeitschrift für Elektrotechnik* (Vienna), of the 1st April, and in that of the *Centralblatt für Elektrotechnik* of the same date, the firm of Messrs. Ganz and Co., of Buda-Pesth, come forward with a dynamo, which, if different in details, is yet in design similar to the ring dynamo, and they state that in 1884 the question occurred to them to construct a dynamo capable of giving the greatest possible output, whilst having the least possible weight.

The *Centralblatt* accompanied this article by a foot note, to which it is desirable to give the widest possible circulation, while reproducing exactly the punctuation:—"Editorial note. The firm of Siemens and Halske is at present engaged in bringing out the same construction!!"

Messrs. Ganz and Co. maintain in the above-mentioned article that their dynamo is the offspring of the alternate current machine of the Zipernowski type, which they have constructed. It might equally well be said that the much older Gramme alternate current machine, which has a Pacinotti ring outside, and electro-magnets inside, is a much nearer parent to their new dynamo. Moreover, the Zipernowski machine, constructed in 1882 or 1883, had a striking family resemblance to the well-known Siemens alternate current machine, as it was modified in the German patent of the 3rd April, 1878, and as it was constructed by Messrs. Siemens and Halske prior to Messrs. Ganz and Co., and shown at the Vienna Exhibition in 1883.

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THE MICRO-TELEPHONE PUSH-BUTTON OF DR. CORNELIUS HERZ.

This apparatus, says *La Lumière Electrique*, is a revised and augmented edition of the telephone push-button of the same inventor. In addition

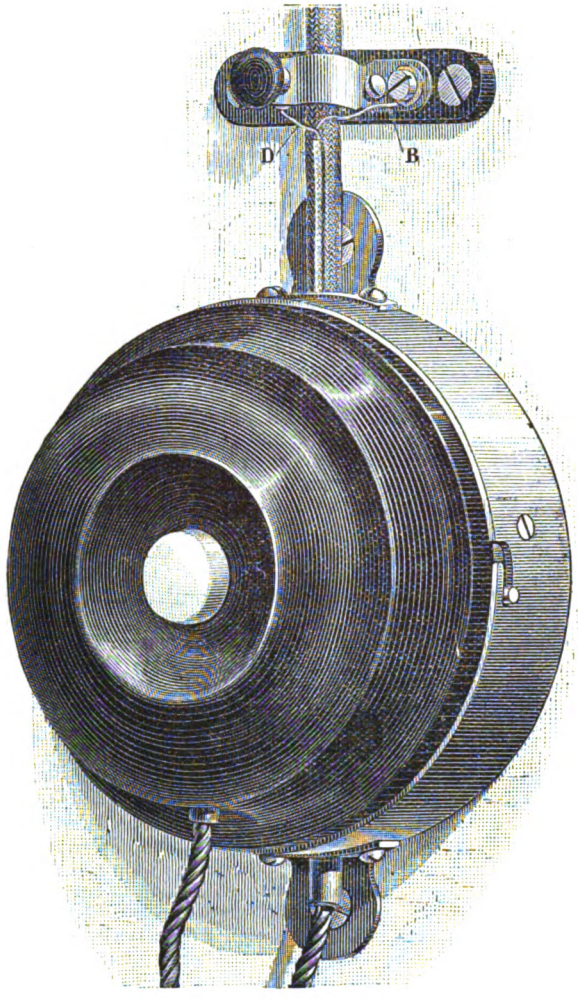

FIG. 1.

to the bell contact, automatic accumulator and telephone, serving alternately as transmitter and as receiver of the latter-mentioned instrument,

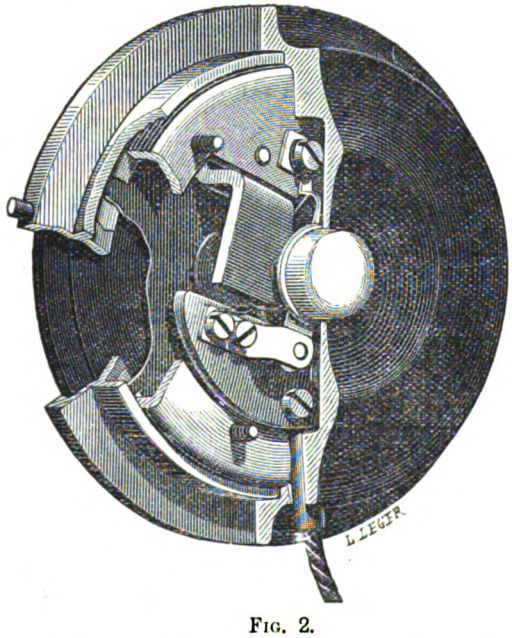

FIG. 2.

the micro-telephone push-button, which is also intended mainly for domestic use and private installations, includes a microphonic transmitter

It constitutes in itself a complete set of telephone apparatus for a station, with the exception of the battery, whilst providing at the same time an

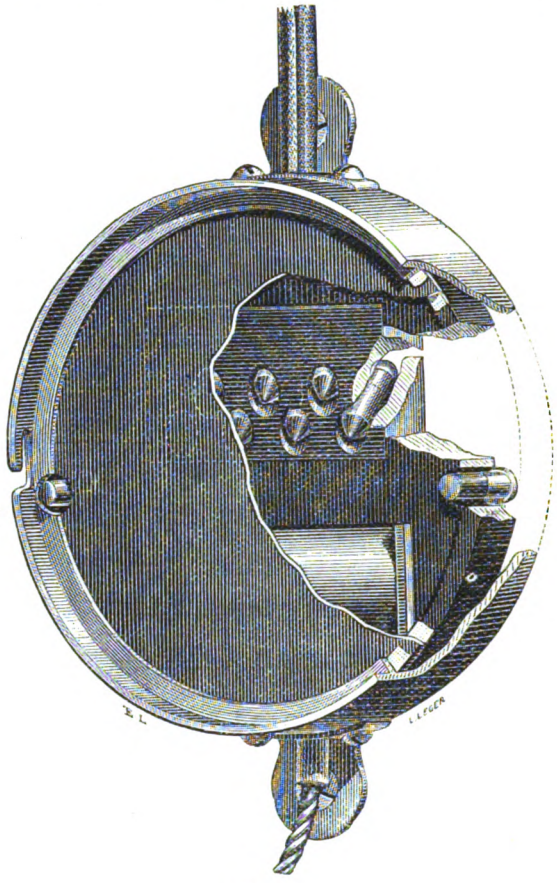

FIG. 3.

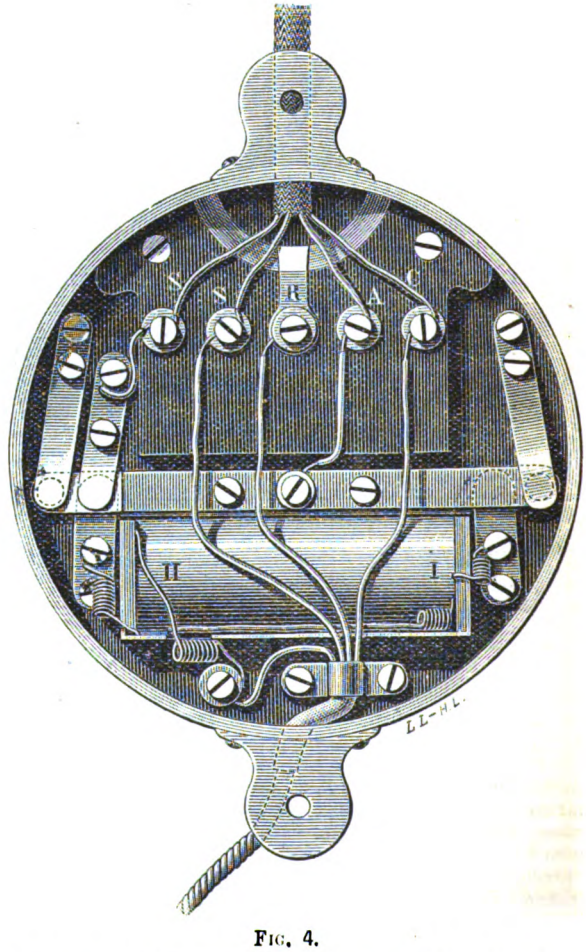

FIG. 4.

electric bell system. The object of the present article is to show that with

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stations of this kind and a central battery the current can be utilised for working the microphones at the different stations, and that communication can be established at will between the different apparatus either through the intermediary of a central station or without such intermediary.

Fig. 1 is a full-sized view of the apparatus to be attached to the wall or doorpost of a room. It is composed of two parts, one which is fixed, containing the microphone and the automatic commutator, the other, which is movable, containing the telephonic receiver and the bell-push, the two portions being connected by a flexible conductor.

Fig. 2 represents the movable part of the telephone contact button alone. Figs. 3 and 4 show a front and back view of the fixed portion, with two holes through which project two little nipple contacts, which operate the automatic switch. In order to understand the action of this automatic switch, of which the different portions are placed, as shown in Fig. 4, on the back portion of the stand, it will be well to refer to Fig. 5, which shows the connections between two micro-telephonic stations, worked by a single battery.

The commutator is formed by an elastic rod of brass, T, placed horizontally on the front part of the apparatus, and which is moved forward by the nipple contacts when the telephone button is unfastened, and which is moved backwards when this is replaced on its stand.

In regard to Fig. 5, we will suppose that Station No. 1 calls to Station

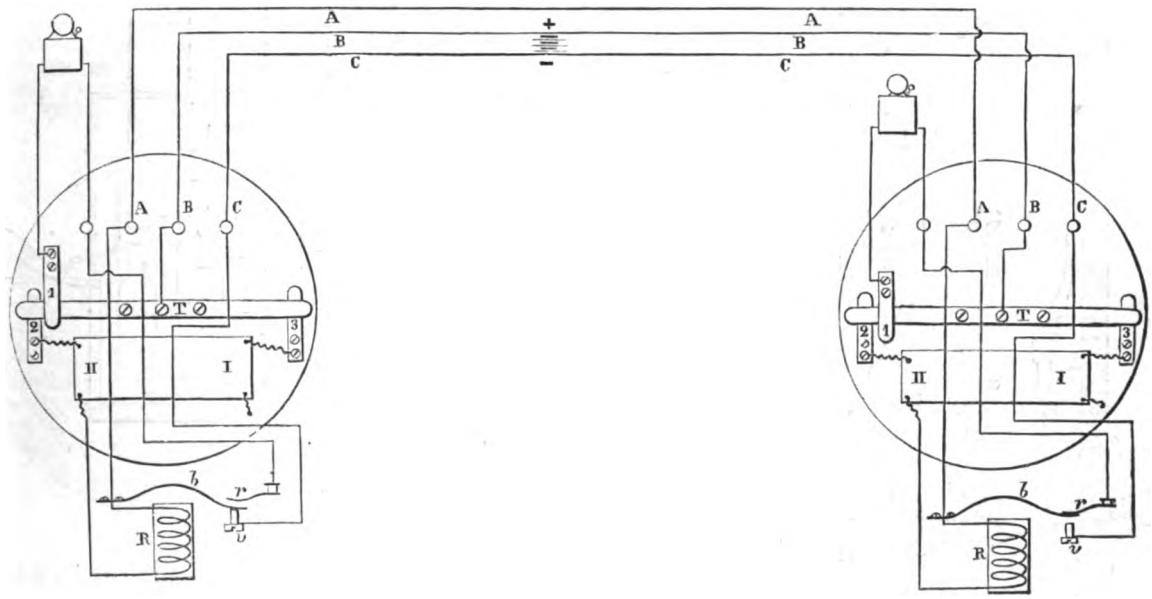

FIG. 5.

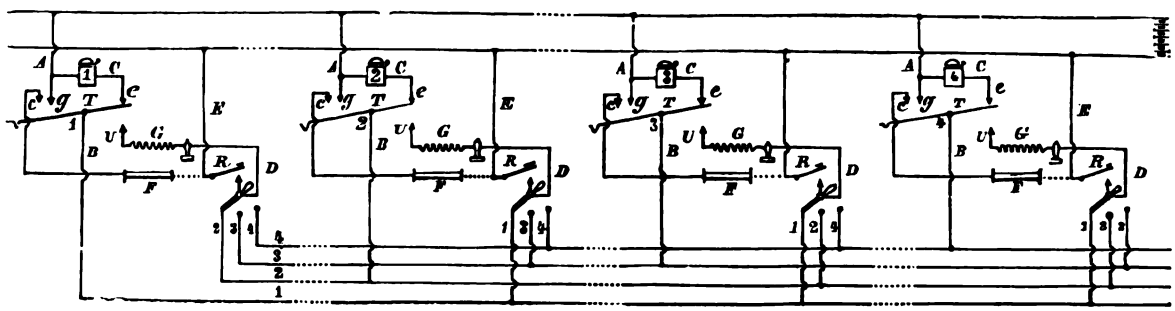

FIG. 6.

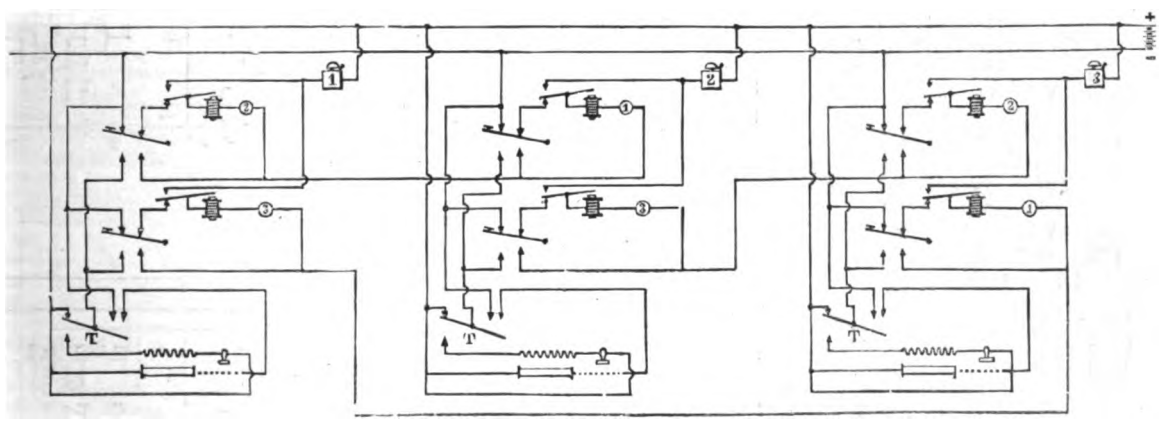

FIG. 7.

including, as we have said, the microphone, the induction coil, and the automatic commutator. Fig. 3 explains the construction of the microphone, which is formed of a carbon diaphragm 2 millimetres in thickness placed at a distance of 1 5 millimetre from the block, which is also of carbon, the variable resistance of the contact being formed by a group of small pencils of carbon, movable within inclined apertures. The positive ends of these pencils bear against the diaphragm, being pressed in contact with it by the effect of their own weight and that of small leaden balls placed above them.

On the carbon block just mentioned is placed the induction coil. The carbon plate is perforated at opposite ends of its horizontal diameter

No. 2. The push-button (Fig. 1) is pressed inwards, thus bringing the spring *b* (Station 1) against the screw *v*, thus breaking contact *r*, so as to put the bell of Station 1 out of circuit, and close the circuit of the battery through the bell of Station 2.

It is easy to see that we have a closed circuit starting from the positive pole of the battery and through the wire B, the commutator T, the Station 2, contacts I, the ball, the springs *r* and *b* of this same station, and returning to the negative pole of the battery through the wire A, the spring *b*, the screw *v* of Station 1, and the wire C.

When the telephone button is removed the ball is placed out of circuit by the motion of the commutator T, which breaks contact with *i* and

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establishes contact with the springs 2 and 3, thus closing the primary circuit and the secondary circuit of the induction coil, 1 and 2. The primary circuit is established as follows:—From the positive pole of the battery to the wire *b*, the commutator T, and the contact spring 3, then through the coil, of which the other end is connected with the carbon diaphragm. From this diaphragm the circuit is completed by the variable resistance contacts and the wire *c*, which communicates with the negative pole of the battery.

It will be seen that, according to this arrangement the primary and the

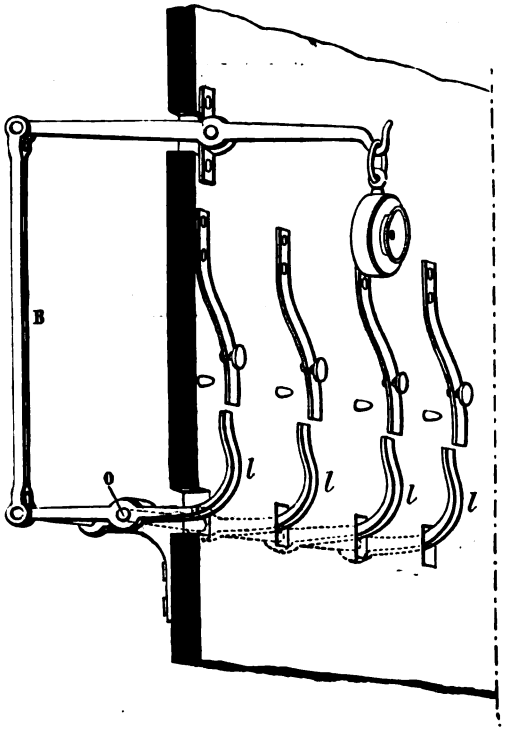

FIG. 8

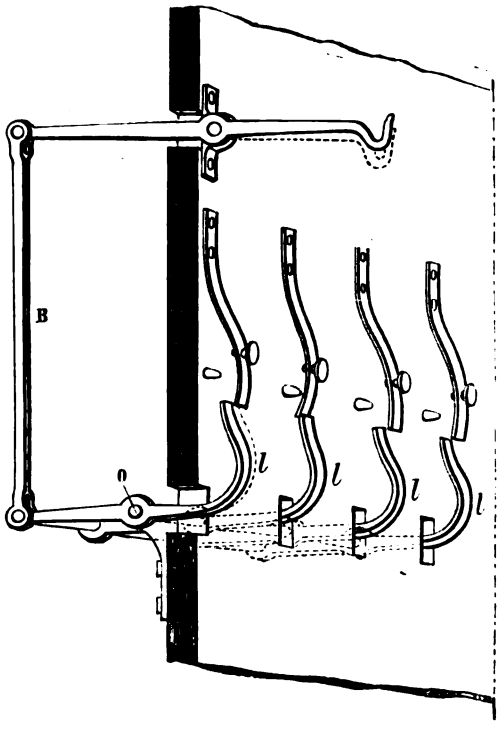

FIG. 9.

secondary circuits have one position in common, which position is represented by the wire B. This is an arrangement much used in America, allowing wire to be economised, and not offering any disadvantage. The play of the commutator T is ensured by the mode of attaching together the movable and fixed portions of the micro-telephone button. As is shown in Fig. 1, the two portions are fastened together by means of a bayonet joint.

The advantages exhibited in Fig. 5 are very simple, representing a case which would but rarely occur in practice. Practically, there would almost always be a certain number, *n*, of stations which would have to be connected together and with a single battery in such a manner that each station would be able to call either of the others. The problem to be solved admits of several solutions, some of which are explained at considerable length in the article by our contemporary. Thus, for instance, Fig. 6 applies to the case in which a central station is out of the question. Here T represents the automatic switch, F the microphone and the primary

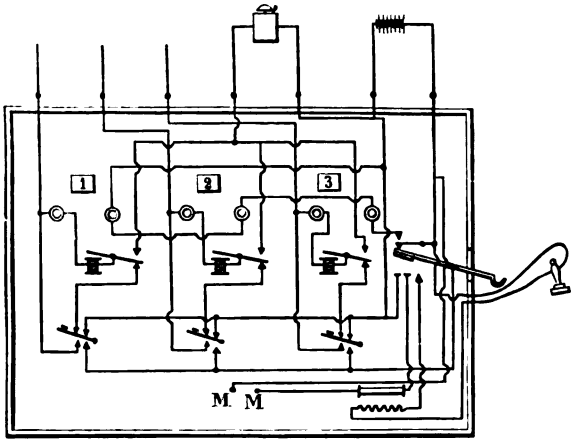

FIG. 10.

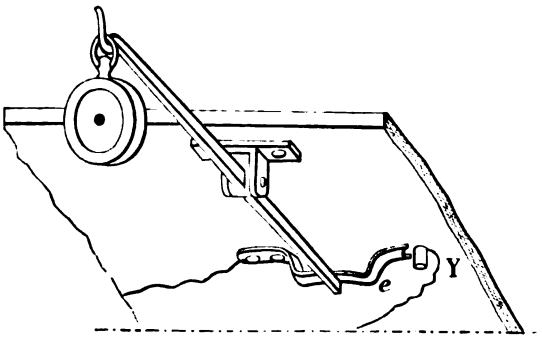

FIG. 11.

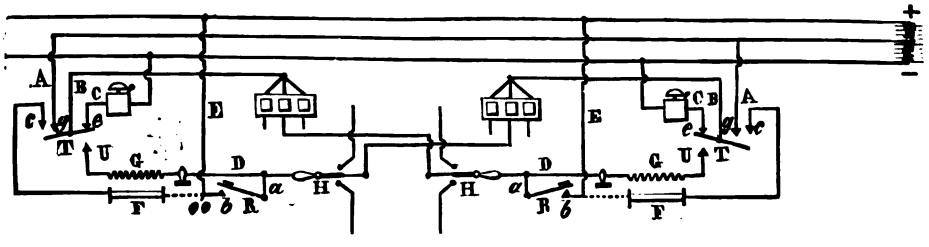

FIG. 12.

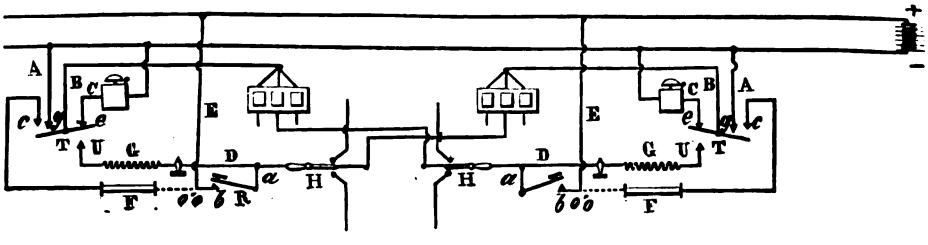

FIG. 13.

circuit of the induction coil, G the secondary circuit of the coil, R the call push, and D a switch having $n-1$ branches for a given number, *n*, of stations. If it is required that each station should be informed by means of an annunciator as to the locality whence the call comes, then the installation represented in Fig. 7 becomes somewhat more complicated. The switch T is still in its position, but instead of the single push of the micro-telephonic button we have as many contact pushes as there are lines,

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less one. The lines are connected to an annunciator through a small electro-magnet, the armature of which closes the circuit of the bell when the current passes. This prevents the bells of the other stations ringing when any one calls another. A single electro-magnet can, however, be used, around which would be placed all the coils of wire corresponding to the different lines. When the push call is pressed the circuit of its own bell is opened, and the number of its annunciator corresponding to the station to be called is short-circuited in order not to show the number there.

The commutator T acts as before, but the push must be kept down all the time the conversation lasts.

Figs. 8 and 9 show a plan for keeping down the pushes during conversation, and for raising them afterwards. The commutator T commands by means of B a series of elbowed levers *l*, movable about a common axis *o*. When the telephone is hooked the levers *l* allow of sounding freely, but when the telephone is unhooked the levers prevent the raising of the lowered buttons, or lowering of those which are up. On re-hooking the telephone after speaking this locking is undone, the numbers are returned, and the apparatus is placed in the waiting position. This plan requires (and this is the drawback to the system) $n\left(\frac{n-1}{2}\right)+2$ wires for n stations, a number increasing rapidly with the value of n. When the number of stations is quite small they can be connected two by two, a plan necessitating $n(n-1)+3$ or $n(n-1)+2$ wires, according as the microphones are capable of supporting a fraction of the current (Fig. 12), or that of the whole battery (Fig. 13).

Fig. 10 shows the arrangement of an automatic microphonic station on this system. The terminals M M are those which are connected with the microphone wires. The contact Y, Fig. 11, serves to replace the numbers which have been exposed. The clutch *c* of the telephone hook is a spring fixed on one side only, which does not come into contact with Y by the weight of the telephone alone, although by a slight pressure when the telephone is hooked up after a conversation the circuit of the recall coils is momentarily closed, and the numbers drawn out thus replaced.

(*To be continued.*)

MODES OF MEASURING THE CO-EFFICIENTS OF SELF AND MUTUAL INDUCTION.*

By Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., Members.

This paper does not resemble Prof. Hughes's inaugural address, in containing a charming account of new experimental researches into the laws of self-induction and of the extra resistance offered to a rapidly-varying current. Its aim is different, it is meant to help the practical electrician to obtain as clear a conception of self-induction as he now has of resistance, and to this end the paper contains the description, and theory of the action, of a simple apparatus that we devised a year ago, and which we have been since improving, for the *direct* measurement of the coefficients of self and of mutual induction in terms of the legal unit.

The electrician of to-day is so familiar with the idea of resistance, that he is liable to forget the time when people had no clear conception that the resistance of a conductor was one of its definite properties, like its weight and length. In the "Reports of the Committee on Electrical Standards," edited by the late Prof. Fleeming Jenkin, a most interesting account is given of the gradual growth of the conception that a conductor had a definite resistance; and in our paper on "A New Determination of the Ratio of the Electromagnetic to the Electrostatic Unit of Electrical Quantity," read before this society in 1879, something is said about the development of this idea of resistance. And during the fifty years that have elapsed since Lenz employed the one foot of No. 11 copper wire as his unit of resistance, the electrical world has not only learnt to regard resistance as a definite property of a definite piece of matter in a definite state, but has become so fully imbued with this idea, that it positively resented Prof. Hughes' experimental proof, last year, that the resistance of a conductor for an intermittent current was a variable.

Now, how has this clear perception about resistance been acquired? We believe by the measuring of hundreds of thousands of resistances during the last twenty-two years in terms of a unit of resistance with a simple name; and we feel that it will not be until many measurements of the coefficients of self-induction of various coils, electro-magnets, dynamos, &c., have been made by practical men, as part of their regular work, and expressed in a unit of self-induction having a simple name, that they will come to have the same instinctive feeling about self-induction that they now have about resistance. There are two reasons why such measurements have not been regularly made; one is, that the importance of a knowledge of the coefficient of self-induction of a circuit is only beginning to be generally appreciated; the other, that the methods of measuring the coefficient have not been very easy to employ. But now that the speed of telegraph signalling is becoming greater and greater, that long-distance telephony is receiving more and more attention, and that the system of distributing electrical energy with secondary generators and alternating currents has become a most important rival to other systems, the regular measurement of the coefficients of self and of mutual induction of dynamos, electro-magnets, induction coils, &c., has now become quite as important to the electrical engineer as the measurement of resistance.

Prof. Hughes' telephone methods for comparing the self-induction of one circuit with that of another are marvellously sensitive, as shown by the results he obtained, but the very delicacy of the methods prevents their being used without a compensator or adjustable standard of mutual induction for the commercial measurement of a coefficient of self-induction in terms of the product of a time into a resistance.

On turning to the electrician's "stand-by," Clerk-Maxwell, one finds a complete exposition of the general principles of self-induction, also several methods for determining what he calls "the electro-magnetic capacity of self-induction of a coil." The very length of the name makes one fear that the methods will be impracticable for every-day work, and that is the case; for the only one which is suited to a practical man, as far as the apparatus is concerned, is unsuitable from a difficulty met with in carrying it out. The method in question is called "comparison of the electrostatic capacity of a condenser with the electromagnetic capacity of self-induction of a coil,"* and the result expresses the coefficient of self-induction as equal to the product of two resistances into the capacity of a condenser. A number of attempts to employ this method were made rather more than a year ago by one of our students, Mr. Sumpner, but the necessity of having to make two separate adjustments of the resistances of the Wheatstone bridge, one in order that there should be no deflection of the galvanometer for steady currents in the arms, the other that there should be no deflection on making or breaking the battery circuit, and the fact that altering the resistances to make either of these adjustments generally disturbed the other adjustment previously made, rendered the method nearly hopeless.

If not merely the resistance of the arms of the bridge were adjustable, but also the capacity of the condenser, so that it might be made to have different known values, this method might give good results if a galvanometer with a long periodic time of vibration were employed. If, however, an ordinary bridge galvanometer were used, the difference that exists in the rate of charging of a condenser and the rate of variation of the extra current due to self-induction would make it impossible for the resistances and the capacity of the condenser to be generally adjusted, so that there was no deflection of the galvanometer on making and breaking the battery circuit, as there would first be a deflection on one side of the zero, then on the other, consequently a very accurate measurement of the coefficient of self-induction could not be made. Modifications of this method, by combining resistances and one or more condensers with a differential galvanometer, have been suggested and tried with more or less good results, but, as explained later on, with none of these methods can the effect be made *cumulative*, and the test therefore very sensitive, by using the plan of rapidly making and breaking the battery circuit.

Probably the best method yet published for measuring the coefficient of self-induction in terms of the product of a time into a resistance is that described by Lord Rayleigh in his paper on "Experiments to Determine the Value of the British Association Unit of Resistance in Absolute Measure," given in *Philosophical Transactions* for 1882, and abstracted by one of us for the *Journal* of the Society, where it will be found on page 152 of the volume for that year. This method, based on one devised by Clerk-Maxwell, but not described in either the first or second edition of his book, consists in placing the coil with self-induction in one of the arms of a Wheatstone bridge, and first obtaining balance in the ordinary way, the battery circuit being completed *before* the galvanometer circuit, then measuring the swing of the galvanometer needle when the battery circuit is completed *after* the galvanometer circuit, and lastly measuring the steady deflection obtained when one or more of the arms of the bridge is altered by a known amount, the battery circuit being completed before the galvanometer circuit, as in the first test.

This method is simple, but it has three great disadvantages. First, while an ordinary Wheatstone bridge is employed, an ordinary dead-beat Wheatstone bridge galvanometer is totally unsuitable, since on making or breaking the battery circuit, when performing the second test, the galvanometer needle must not begin to move until the extra current has ceased; and further, the time of vibration of the galvanometer needle, and the logarithmic decrement, have to be determined, as they both enter into the formula, so that, in fact, a ballistic galvanometer must be employed. Second, if the coefficient of self-induction to be measured be small, the swing of the galvanometer needle obtained on making or breaking the battery circuit will be very small, and cannot be accurately read. And the effects cannot be made *cumulative* by rapidly making and breaking the battery circuit when using either this method or the one described in Clerk-Maxwell, referred to above, or any simple modification of these methods, since the swings of the galvanometer needle are in opposite directions on making and on breaking the battery circuit. Third, in making the first test with the Wheatstone bridge a *very accurate* balance must be obtained, since the swing obtained on making the second test must be *entirely* due to the effect of self-induction. Consequently a sliding wire in addition to the ordinary bridge must be employed, instead of using the simple interpolation method of obtaining the last decimal place from the small steady deflections to the right and left of the true zero. *(See Appendix II.)*

* Paper read before the Society of Telegraph-Engineers and Electricians on April 28th, 1887.

* A student might naturally conclude that, as a capacity measured *electrostatically* is of the same dimensions as a coefficient of self-induction measured *electromagnetically*, both being a simple length, it was this comparison that Clerk-Maxwell referred to; but that is not the case, as shown by the working out of the problem, consequently the answer contains the square of a resistance in addition to the capacity of the condenser and the coefficient of self-induction of the coil. Hence the problem is not strictly the comparison of the electrostatic capacity of a condenser with the electromagnetic capacity of self-induction of a coil.

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A circuit containing self-induction acts as if it had a larger resistance than its true one when a current is started in it, and a smaller resistance when the current is stopped. Hence, if balance be obtained with a Wheatstone bridge in the ordinary way, the fact of any of the arms possessing self-induction, or of any one of the arms having a condenser attached to it, will produce no effect on the balance if the battery circuit be rapidly made and broken, provided that the rapidity of make and break be not too great for the currents in the arms of the bridge to reach their steady values each time that the battery circuit is made, and to die away each time that it is broken. If the currents have not time to reach their steady value when the battery circuit is closed, and to die away when it is broken, then self-induction in any one of the arms will produce a disturbance in the balance; but such a method of measuring a coefficient of self-induction would lead to very complicated formulæ, and is not worth developing with the view of obtaining a simple method of measuring self-induction.

It therefore occurred to us to consider whether, without employing such rapid makes and breaks as would prevent the currents reaching their steady values, the self-induction of a circuit might not be made to act as an apparent steady definite increase of the resistance of that circuit which could be measured in the ordinary way with a Wheatstone bridge or differential galvanometer, and by this means the measurement of a coefficient of self-induction would simply resolve itself into the measurement of a resistance. And this problem we solved in the following way, in the spring of 1886:—

The coil, the coefficient of self-induction of which it is desired to measure, is placed in one of the arms of a Wheatstone bridge, the three other arms consisting of ordinary doubly-wound resistance coils possessing no appreciable self-induction, and not only is the battery circuit rapidly made and broken, but, in addition, after each closing of the battery circuit the galvanometer circuit of the bridge is either short-circuited or broken, so as to cut out the galvanometer, and after each breaking of the battery circuit the galvanometer circuit is either unshort-circuited or closed again, so that the galvanometer is now operative again. In this way all the successive impulses of the galvanometer needle that are produced on starting the current in the coil with self-induction produce their *cumulative* effects, but the successive impulses of the needle that, under ordinary circumstances, would be produced on the needle in the opposite direction are cut out. Hence the self-induction possessed by one of the arms causes that arm to apparently increase in resistance by a definite amount depending on the coefficient of self-induction and the number of operations performed per minute. This apparent increase of resistance produces a deflection of the galvanometer which can be noted, and its value ascertained by comparing it with the deflection produced with steady currents when one or more of the arms of the bridge is altered by a known amount, as in making the Rayleigh test described above. But since the necessity of having to read the deflection limits the speed of performing the double make and break operation, in order that the spot of light may not be sent off the scale, we soon replaced this comparative deflection *cumulative* method* by a much more sensitive *zero cumulative* method, and instead of reading the galvanometer deflection we re-establish the balance and bring the needle back to zero, by altering one or more of the arms of the bridge, as in making an ordinary resistance test with a Wheatstone bridge.

In our experiments we have also preferred the periodical short-circuiting of the galvanometer to breaking the galvanometer circuits, since, as there is a current flowing in the galvanometer when this operation is performed if the zero method be employed, the breaking of the galvanometer circuits would produce a spark which would make the calculations difficult, whereas, as will be seen, the periodical short-circuiting of the galvanometer produces an effect that can easily be taken into account in the mathematical investigation.

The measurement of a coefficient of self-induction in this way is extremely simple, because on the condition that the periodic time of our operation is not too short for the currents to become steady in the interval between the closing of the battery circuit and the short-circuiting of the galvanometer, and to die away in the interval between the breaking of the battery circuit and the unshort-circuiting of the galvanometer, we have shown that the following *remarkably simple* formula is very approximately true:—

$$L = T\sigma \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where L is the coefficient of the self-induction of the coil in ohm seconds, or earth quadrants, the commercial unit of self-induction, T the time in any one operation that the galvanometer is non short-circuited while the battery circuit is closed, and σ the apparent increase of resistance of the coil in ohms. It will be observed that when L is small the measured increase of resistance, σ, may be made quite large enough to be accurately measured by making T small. This may be done either by performing the operation rapidly, or, as will be seen later on, by altering the adjustment in the particular apparatus which automatically performs the required operation. *Hence this method is an extremely delicate one for the absolute measurement of a coefficient of self-induction, and the coefficient is expressed in its simplest possible form, namely, as the product of a time into a resistance.*

If instead of periodically cutting out the galvanometer circuit while the battery circuit is being broken, we cut it out while the battery current is being made, and allow the galvanometer to be operative while the battery circuit is being broken, the resistance of the coil possessing self-induction will apparently become less by a definite amount, and in this case σ will be the apparent diminution of its resistance, and T is the time the galvanometer is operative after the battery circuit is broken.

The first apparatus for enabling measurements of self induction to be made in this way was constructed in the spring of 1886, under the superintendence of one of our assistants, Mr. Mather. It consisted of a double commutator, shown in Fig. 1, the spindle S, to which the commutators were locked by the nut N, being rotated at any speed by a small electromotor not shown in the figure, to which was attached a Young speed indicator, which registered the speed of rotation at any moment. The brushes, B_1, B_2, b_1, b_2, were fixed to the baseboard and joined to the bridge, as indicated in the figure. When the double commutator was rotated by the motor (of which the speed was correctly adjusted by means of a Varley flexible carbon-resistance), the portion A B caused the battery circuits to be periodically made and broken, while the other portion, C D, periodically short-circuited and unshort-circuited the galvanometer, so that the following cycle of operation, called for simplicity *one operation*, was performed any desired number of times per minute.

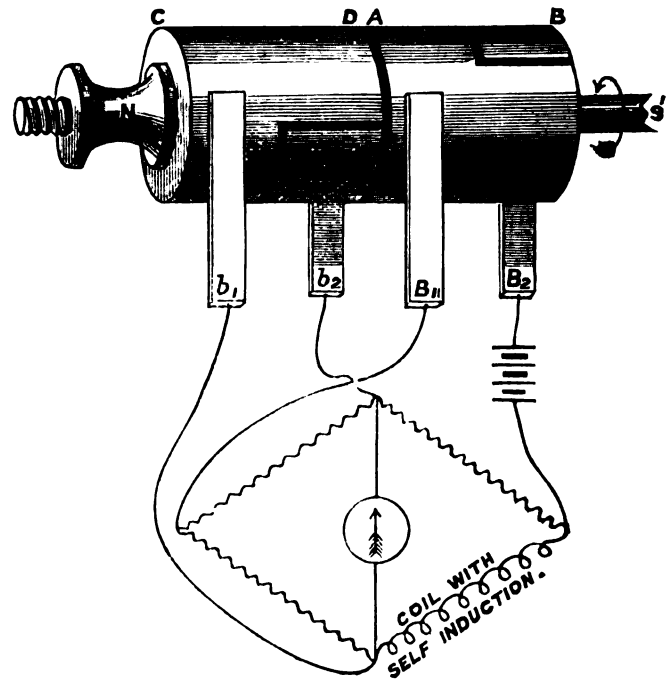

FIG. 1.

Battery Circuit.	Galvanometer Short Circuit.
Make.	While broken.
While made.	Make.
Break.	While made.
While broken.	Break.
Make.	While broken.

The time T in the formula given above is the interval that elapses in one rotation between the time when the continuous part of the commutator A B comes into contact with the brush B_2, and the time when the continuous part of the commutator C D comes into contact with the brush b_2. This time can be made shorter or longer by varying the speed of rotation, but it can also be varied by loosening the nut, N, and shifting one of the commutators round relatively to the other, and then screwing up the nut again. Indeed, it was for the purpose of enabling this adjustment to be easily made that double springs were in each case employed, instead of making one contact through the spindle.

At about this time—that is, in the summer of last year—we invited Mr. Sumpner, one of the third year students of the Central Institution, to experiment with this apparatus, and generally, by experimenting and by working at the subject mathematically, to find out the capabilities of this new method of measuring self-induction, also to see whether by possibly using the apparatus in some other way the method could be made even still more sensitive. We take this opportunity of thanking Mr. Sumpner for the energetic way in which he has worked at the subject, and for the very large number of experiments on the accuracy of various modes of measuring self-induction which he has conducted, with the occasional aid of two other of the third year students, Messrs. Rossiter and Watney.

* Since this paper was announced to be read, M. Lipmann has communicated to the French Academy a paper "Sur la Détermination du Coefficient du Self-induction," by MM. P. Ledeboer and G. Maneuvrier, describing a new method which these experimenters have devised. An examination of it, however, shows that it is identical with our *less sensitive* 1886 method. After giving some very accurate results that they have obtained by using the new method of testing, they say:—"Nous l'avons préferée d'ailleurs aux autres méthodes pour le mésure des faibles coefficients de self-induction, et notamment à la méthode de M. H. F. Weber (modification de celle de M. Hughes), parce qu'elle conduit à une formule très simple et qu'elle nécessite, en dehors du pont du Wheatstone, d'autre disposatif expérimental qu'un interrupteur tournant."

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The various methods of testing which Mr. Sumpner has employed, the mathematical development of the formulæ used by him in each case, and his general conclusions as to the accuracy of the various methods, are given later on in the Appendix; but one interesting result that he has arrived at may here be mentioned, viz., that although the apparatus has during the past twelve months been gradually totally altered in detail, the experiments have shown that the principle originally proposed for carrying out the measurement, requiring the cycle of operations given in the foregoing table to be periodically and rapidly performed, is the simplest and most accurate one to employ. One reason for the accuracy of the method is that neither commutator is in any one of the arms of the bridge, so that no ordinary change in the resistance of the contacts produced by oil or dust, &c., getting in between the springs and the rotary barrels can introduce any error into the test. Of course an actual failure of contact might lead a careless experimenter to a wrong result, but so might a disconnection in the battery or galvanometer circuit in an ordinary Wheatstone bridge, if the conclusion was drawn that, because there was no deflection on pressing down the key, balance had been obtained.

The first thing to be done after constructing the apparatus, was to ascertain what was the formula connecting the unknown coefficient of self-induction with the apparent increase of resistance of the coil, and the time in which the cycle of operations was performed.

This formula we calculated ourselves, neglecting the self-induction of the galvanometer, since we felt that its effect could not be serious. Mr. Sumpner, on the other hand, took up the complete problem, and we give his proof reduced to its simplest form, since, in addition to its application to the experiment in question, the calculation is interesting in connection with the problem of measuring the capacity of a condenser with a Wheatstone bridge and vibrating wippe, which will be found worked out by Clerk-Maxwell, without, however, any notice being there taken of the self-induction of the galvanometer, the effect of which, therefore, on the answer is not considered.

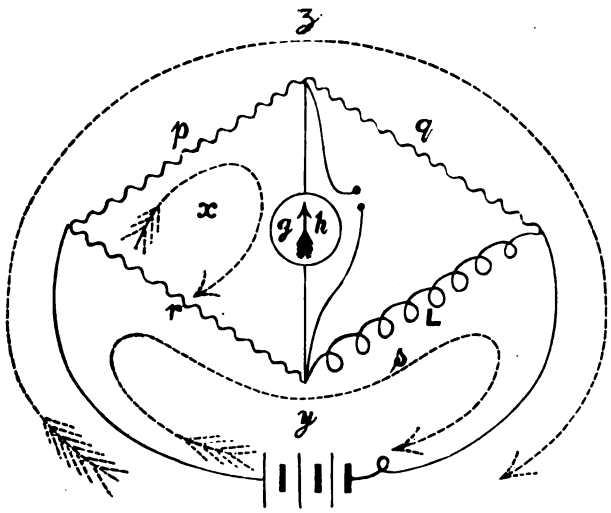

FIG. 2.

Fig. 2. shows the Wheatstone bridge, s being the resistance of a coil with a coefficient of self-induction L; p q and r are the resistances of the three other arms of the bridge when they are so adjusted that there is no deflection of the galvanometer on rotating the commutators at a certain speed. On rotating the commutators a current will sometimes pass one way through the galvanometer and sometimes the other, but with the particular speed of rotation p, q, and r are such that the total quantity passing through the galvanometer is nought. The resistance and coefficient of self-induction of the galvanometer are g and λ, and the electromotive force and resistance of the battery E and b. Then if x, y, z be the imaginary currents on the meshes,*

$$r(x-y)+p(x+z)+gz+\lambda\frac{dx}{dt}=0$$

$$b(y+z)+r(y-x)+sy+L\frac{dy}{dt}=E$$

$$b(y+z)+px\qquad+qz\qquad=E.$$

Eliminating y and z, we have

$$Ax+B\frac{dx}{dt}+P\frac{d^2x}{dt^2}+C\quad=0\quad\ldots\ldots\quad(2)$$

where $$A=\begin{vmatrix} r+p+g & -r & p \\ -r & s+b+r & b \\ p & b & p+q+b \end{vmatrix}$$

$$B=\lambda\begin{vmatrix} s+b+r & b \\ b & p+q+b \end{vmatrix}+L\begin{vmatrix} p+g+r & p \\ p & p+q+b \end{vmatrix}$$

$$P=(p+q+b)L\lambda,$$

$$C=E(ps-qr).$$

* For the method of solving such problems by the employment of these imaginary currents, see a most interesting paper by Dr. Fleming, in the *Proceedings* of the Physical Society, Vol. VII., p. 215.

Integrating (2) we obtain

$$A\int x\,dt+B\int dx+P\int\frac{d^2x}{dt^2}dt+\int C\,dt=0\quad\ldots\ldots\quad(3)$$

The effect on the galvanometer needle may be divided into two parts—one, the first rush of electricity that occurs through it when the battery circuit is closed during the time the galvanometer is not short-circuited, and the diminution of this current through zero and its increase in the opposite direction until it reaches a certain definite value, when the currents in the arms of the bridge have become steady; the second, the dying away of this reverse current in the galvanometer while it is short-circuited. These two effects we shall consider separately.

To ascertain the amount of the first effect, we must integrate between t equals nought and t equals T, since, by hypothesis, T is the interval that elapses between the closing of the battery circuit and the short-circuiting of the galvanometer.

Integrating between these limits we have

$$\int_0^T x\,dt=Q_1,$$

where Q_1 is the quantity of electricity that flows through the galvanometer in the time T,

$$\int_0^T dx=-\frac{C}{A},$$

since this is the final steady value of the current x, which is nought at time nought.

Also $$\int\frac{d^2x}{dt^2}dt=\frac{dx}{dt}$$

and $$\frac{dx}{dt}=0 \text{ at time T},$$

since, by hypothesis, T is long enough for the currents to become steady. To find the value of $\frac{dx}{dt}$ at time nought, we have the fundamental differential equation for the current through the galvanometer

$$gx+\lambda\frac{dx}{dt}=V,$$

where V is the potential difference at the terminals of the galvanometer at any time. And since where t equals nought x equals nought, we have at time nought

$$\frac{dx}{dt}=\frac{V_0}{\lambda},$$

where V_0 is the value of the potential differential at the terminals of the galvanometer at time nought

and $$V_0=-\frac{Ep}{p+q+b},$$

since at time nought both x and y are nought, therefore at time nought

$$\frac{dx}{dt}=-\frac{Ep}{\lambda(p+q+b)},$$

and therefore $$\int_0^T\frac{d^2x}{dt^2}dt=-\frac{Ep}{\lambda(p+q+b)}.$$

Lastly $$\int_0^T dt=T,$$

therefore equation (3) reduces to

$$AQ_1-B\frac{C}{A}+P\frac{Ep}{\lambda(p+q+b)}+CT=0.$$

Next, let us consider the dying away of the current in the galvanometer after it is short cuited. We may now use simply the equation

$$gx+\lambda\frac{dx}{dt}=0,$$

if the resistance of the short circuit be very small compared with that of the galvanometer itself.

Multiplying by dt, and integrating from t equal T to t equal T', say the time the short circuit is removed, we have

$$gQ_2+\lambda\int dx=0,$$

where Q_2 is the quantity of electricity that passes through the galvanometer while short-circuited. At the moment after short-circuiting

$$x=-\frac{C}{A},$$

the steady value of the current, since the self-induction of the galvanometer prevents any instantaneous change in the current passing through it, and when t equals T' the current in the galvanometer is nought, since, by hypothesis, the time of short-circuiting T' - T is long enough for the current in the galvanometer to die away,

$$\therefore\int_T^{T'}dx=-\left(-\frac{C}{A}\right).$$

Now, in order that there may be no deflection of the galvanometer, we must have

$$Q_1+Q_2=0,$$

$$\therefore\frac{BC}{A^2}-\frac{P}{A}\frac{Ep}{\lambda(p+q+b)}-\frac{C}{A}T=\frac{\lambda}{g}\cdot\frac{C}{A}\quad\ldots\ldots\quad(3)$$

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Let σ be the apparent steady increase of the resistance of the coil with self-induction (of which the ordinary resistance is s) produced by the rotation of the commutator at speed corresponding with the times T and T^1, then

$$p(s+\sigma)=rq,$$
$$\therefore C=-Ep\sigma.$$

Substituting this value for C, and for P its value $L\lambda(p+q+b)$ in equation (3), we have

$$L=\sigma\left(T+\frac{\lambda}{g}-\frac{B}{A}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Now $\frac{\lambda}{g}$ and $\frac{B}{A}$ are usually small compared with T, therefore when this is the case

$$L=\sigma T,$$

the simple formula previously referred to.

Referring to Fig. 1, it will be seen if the brushes B_2 and b_2 touch over a small area, and if the centres of these areas are in a plane passing through the axis of rotation, that T is simply equal to

$$\frac{\text{angle between the slits in the two commutators}}{360\times\text{number of revolutions per second.}}$$

We may call

$$\frac{\text{angle between the slits in the two commutators}}{360\text{ deg.}}$$

the lead or l, and l will be equal to $\frac{1}{4}$, for example, when each of the cycle of operations given in the table last for one quarter of a revolution.

Introducing l we have, if σ be in ohms,

$$L=\frac{l}{n}\sigma \text{ second-ohms},$$

where n is the number of revolutions of the commutator per second, or

$$L=\frac{60\,l\sigma}{N}\text{ second-ohms} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where N is the number of revolutions per minute.

A large number of experiments were made in May 1886, with a solenoid of which the resistance was about 4 ohms at ordinary temperatures, to see how nearly the coefficient of self-induction determined by using the double commutator arrangement running at different speeds, and with different leads, agreed with the coefficient of self-induction determined by Lord Rayleigh's method, which gave 0 0215 second-ohm for the solenoid alone, and 0 517 second-ohm when a certain iron core was introduced into the solenoid.

The following are some of the results obtained with the solenoid without the iron core when the lead

$l=\frac{1}{12}$ about :—

N	$s+\sigma$	σ	$L=\frac{60\,l}{N}\sigma$
0	4·06		
660	6·70	2 64	0·0200
760	7·00	2·94	
860	7·50	3·44	0 0200
997	8·00	3·94	
1117	8·50	4 44	
1240	9·00	4·94	
1362	9·50	5·44	0·0200
1450	11·00	6·94	
1850	12·00	7·94	0·0204
2335	13·50	9·44	0 0202

Plotting these results on squared paper, we obtain the curve A A A (Fig. 3), the abscissæ representing the values of N, the number of revolutions per minute, and the ordinates the values of $s+\sigma$, the apparent resistances of the solenoid at the various speeds. This curve we see is a perfectly straight line, which means that the increase of resistance is proportional to the speed ; or, in other words, the approximate formula (5) for calculating L may be employed with *any* of the results, and the value of L so obtained from a few of the results is given in the last column of the preceding table. That we may use the approximate formula at all for L shows us that the term

$$\frac{\lambda}{g}-\frac{B}{A}$$

in the expression (4) is negligible in comparison with T ; and that we may use it even for the result obtained with the highest speed of rotation employed, viz., 2,335 revolutions per minute, shows us that $\frac{1}{12\times2335}$ minute, or about 0 0022 of a second, which is the time the galvanometer remains unshort-circuited after the battery circuit is closed, is long enough for the currents in the bridge to reach their steady value.

The values of the coefficient of self-induction obtained, 0 020, are approximately equal to 0·0215 second-ohm, the value obtained by Lord Rayleigh's method, and that they are not exactly the same arises from the difficulty, already referred to, of estimating the lead l accurately with the eye. This would not introduce any inaccuracy in the actual use of the instruments, since for a given adjustment of the relative positions of the commutators A B and C D in Fig. 1, the value of l is a constant, and this value would be determined once for all, not by the eye, but by an actual experiment made with a coil of known self-induction. We were not, however, calibrating the instrument on the assumption that the approximate formula (5) was true, but using the instrument to see how nearly (5) might be employed. In our experiment l was probably not $\frac{1}{12}$ exactly, but more nearly $\frac{1}{11}$.

Experiments were now made with the lead l, equal about to 0·3.

$l=0·3$ about

N	$s+\sigma$	σ	$L=\frac{60\,l}{N}\sigma$
0	4·06		
770	5·00	0·94	
1120	5·50	1·44	
1600	6·00	1·94	Mean value, 0·0218 ohm-second.
2000	6 50	2 44	
2410	7·00	2 94	
2860	7·50	3·44	

These results when plotted give the straight line B B B. Instead, therefore, of calculating the value of L from several of the results, as before, we may more accurately determine it from the point at the end of this line corresponding with a speed of 3,000 revolutions per minute, and an apparent resistance of 7·7 ohms, that is an apparent increase of 3·64 ohms. This gives for L the value 0·0218 second-ohm, also not differing much from the true value 0·0215 second-ohm, considering that the exact value of the lead was not known.

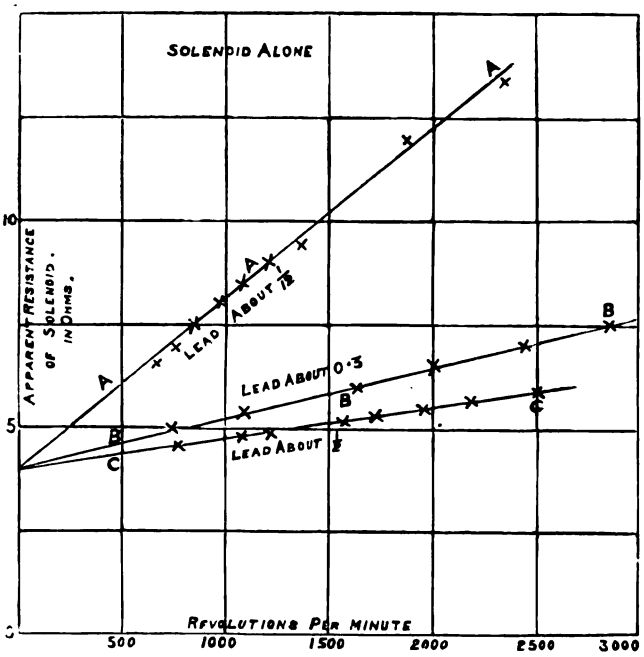

FIG. 3.

Lastly, experiments were made with a lead of about $\frac{1}{2}$, with the following results :—

$l=\frac{1}{2}$ about

N	$s+\sigma$	σ	$L=\frac{60\,l\,\sigma}{N}$
0	4 1		
820	4·7	0 6	0·0219
1100	4 9	0·8	
1240	5·0	1·0	0·0217
1560	5·2	1·1	
1700	5·3	1·2	0·0212
1950	5 5	1·4	
2220	5·7	1·6	0 0216
2500	5·9	1 8	0 0216

Here again the points all lie very nearly in the straight line C C C, and the values given in the last column, calculated from some of the points, are all nearly equal to one another and to the true coefficient of self-induction of the solenoid.

It is clear, therefore, that with speeds up to 3,000 revolutions per minute and higher, and with leads varying from $\frac{1}{12}$ to $\frac{1}{2}$, any single experiment correctly made gives the true value of the self-induction by the use of the simple formula

$$L=\frac{60\,l}{N}\sigma.$$

We see from the formula, and from the experiments which substantiate it, that the smaller the lead and the higher the speed of rotation of the

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commutating arrangement, the larger is the value of apparent increase of resistance—that is, the more sensitive is the test.

The iron core was now inserted in the solenoid, and a series of experiments made with leads equal to $\frac{1}{12}$, $\frac{1}{8}$, $\frac{1}{4}\frac{3}{6}$, $\frac{1}{3}\frac{7}{6}$, in the respective sets of experiments. The results are shown by the curves D D D, E E E, F F F, G G G. It will be observed that, although the speed of rotation of the commutating arrangement did not exceed 680 revolutions per minute, the observations do not lie even approximately in a straight line, until the lead $\frac{1}{4}\frac{3}{6}$ is employed, and even when the last lead $\frac{1}{3}\frac{7}{6}$ is used there is still curvature in the line. This great difference between the curvature of the lines for a range of even slow speeds when the iron core is introduced, and the perfect straightness of the lines beyond the highest speed, 2 800 revolutions per minute, employed with the solenoid alone, arises from the coefficient of self-induction of the solenoid, with the iron core inserted, being about twenty-five times as great as the self-induction of the solenoid alone. Hence the smallest interval, T, between the closing of the battery circuit and the short-circuiting of the galvanometer that can be employed is much larger when the iron core is inserted than when the solenoid alone is used. Consequently the lead must be large or the speed must be slow for the results to lie in a straight line. The curve D D D, obtained with the lead of about $\frac{1}{12}$, is too far from straight for any portion of it to be used in calculating the coefficient of self induction, with the simple formula—in other words, so small a lead was unsuitable to be used. The greater part of the next curve, E E E, is also too far from straight to be used, but the first observation, corresponding with a speed of 156

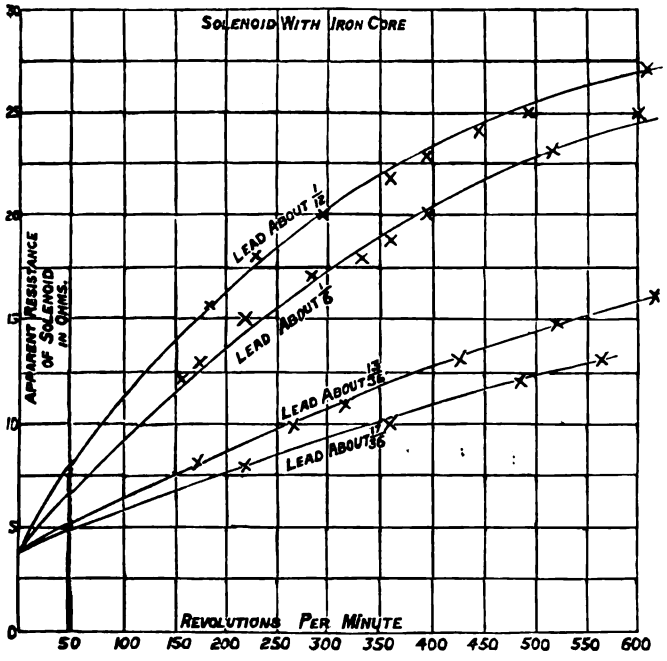

FIG. 4.

revolutions per minute and an apparently increasing resistance of 8 ohms, is on a portion of the curve sufficiently straight to give an answer not much smaller than the truth. The result so obtained is

$$L = \frac{60 \times \frac{1}{6}}{156} \times 8$$

$$= 0{\cdot}513 \text{ second-ohm},$$

which is not very much less than the true value of the coefficient of self-induction of the solenoid with the iron core, as determined by Lord Rayleigh's method, which, as before mentioned, gave 0·517 second-ohm.

With the lead of about $\frac{1}{8}$, the lowest speed at which an observation was taken was 170, corresponding with an apparent increase of resistance of 4 ohms. This gives

$$L = \frac{60 \times 13}{170 \times 36} \times 4$$

$$= 0{\cdot}510.$$

If we take the next speed, 260, corresponding with an increase of resistance of 6 ohms, we find L equal to 0·500.

The last curve G G G, obtained with the largest of the leads, about $\frac{1}{3}\frac{7}{6}$, is the one that, being straightest, will probably give the best results, but as even this is not quite straight we must expect to obtain slightly too low a value. The two first observations correspond with speeds of 220 and 355 revolutions per minute, producing an apparent increase of resistance of 4 and 6 ohms. The values of L obtained from these results are 0·515 and 0·482 second-ohm, from which we should conclude that the true answer was a little higher than 0 515 second-ohm, and this we know is correct, as the true answer is 0·517 second-ohm.

That it is necessary to employ only slow speeds when a large coefficient of self-induction is being measured is no disadvantage, because when the self-induction is large the apparent increase of resistance at even slow speeds is great, and so can be accurately measured.

(To be continued.)

SOCIETY OF TELEGRAPH-ENGINEERS—STUDENTS' MEETING.

The first students' meeting was held in the Society's Library on Thursday, the 5th inst., Prof. W. E. Ayrton, F.R.S., in the chair. Prof. Ayrton briefly addressed the meeting, stating the objects of such meetings, and expressing his warm sympathy with the movement. Mr. J. Rance then opened the discussion upon Dr. Thompson's "Telephonic Investigations," and was followed by Messrs. A. H. Bate, A. C. F. Webb, Wordingham, E. Thomas, and Cooper. Prof. Ayrton replied to several questions, and closed the discussion.

A vote of thanks to Prof. Ayrton terminated a very successful meeting.

COMPANIES' MEETINGS & REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The twenty-seventh ordinary general meeting of shareholders in this Company was held at Winchester House, 50, Old Broad-street, on the 11th inst. under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting, and the minutes of the last general meeting, which were approved by the present meeting and signed by the Chairman.

The CHAIRMAN having stated that that was the twenty-seventh occasion within the last fourteen years upon which his present duty had devolved upon him, continued: It is rather difficult to avoid monotony in discharging this duty on so many successive occasions. However, gentlemen, the monotony has not been altogether of a disagreeable character. I think there have been in the reports and addresses which I have had the honour to make to you elements which have rendered the monotony satisfactory or at least palatable to you. I remember that in the early days of our enterprise our proceedings were somewhat diversified by a not unnatural expression of impatience that our undertaking had not at once realised all the anticipations formed of it. However, that is now a matter of history, for of recent years our proceedings have been tolerably amicable between the Directors and the shareholders, and I think the state of the room on the present occasion proves that the shareholders have no want of confidence in the management of the Directors. Those of you who have taken the trouble to read the present report—which is a condensed history of the transactions of the Company for the last six months—will see that the satisfactory elements to which I have alluded as existing in former reports are not wanting on the present occasion. I am happy to say that we are able to report that all your plant is in excellent condition. We have had during the last six months a complete immunity from any casualty, and our traffic has shown a substantial increase both on the previous half-year and on the corresponding period of the previous year. I may incidentally mention that that satisfactory increase of traffic is still going on, and that up to the present time we are receiving considerably more than we obtained last year. We have been able to pay our usual dividend and to carry a very substantial sum to the reserve fund, and also to carry forward a considerable sum to the current half-year's accounts. Well, under those circumstances I do not think the resolution that I have to propose requires any very great eloquence or argument on my part to enforce it There are one or two incidental circumstances to which I would venture just to allude. We have been threatened with competition in several directions. These threats have not as yet assumed what I may call a tangible form. All I can say about them is that we are exercising the greatest vigilance as to those threatened attacks, and your Board will take such steps in the event of their becoming tangible as they may consider necessary to support the interests of the Company. You are aware that for a long period past we have been engaged in negotiations for strengthening—as I stated on a former occasion—our position in Brazil. Those negotiations have as yet led to no practical result; but we are not without hope that they may do so, and in the meantime we must ask the continued forbearance of the shareholders, for it will be obvious to you that to disclose our hand, and show what our operations are in the midst of a negotiation, would not be a wise or a useful course for us to pursue. I do not think there is any other circumstance that I need allude to, and I beg leave to propose that the report of the Directors and the accounts to the 31st December, 1886, now submitted, be approved and adopted.

Sir JAMES ANDERSON: I beg leave to second that.

The CHAIRMAN, in answer to a question, said that what he had referred to as competition was that there were several proposals to construct new lines which would practically compete with the Company. However, as he had already stated, they had not yet assumed any very decided form. The resolution was then carried unanimously.

On the motion of Mr. GRIFFITH, seconded by Mr. NICOL, a cordial vote of thanks was passed to the Chairman and the Directors.

The CHAIRMAN, in acknowledging the vote, stated that the Directors would continue to do their best, as in the past, to promote the interests of the Company.

The proceedings then terminated.

Submarine Cables Trust.

The sixteenth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the offices of the Trust, Winchester House, No. 50, Old Broad-street, on Wednesday, the 11th inst., Mr. John Pender presiding.

The SECRETARY (Mr. Lewis Wells) read the notice convening the

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meeting, and the minutes of the previous meeting, which were confirmed and signed by the Chairman as correctly entered. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: On referring to the accounts, it will be seen that our revenue for the past financial year amounted to £14,528, against £21,826 in the previous year. As stated in the report, this is mainly owing to the falling off in the dividend paid by the Anglo-American Company, from whom we received only 5s. per cent., against £1. 5s. in 1886; but we have also had diminished returns from our other investments—the Eastern Company has only paid 5½ per cent, against 6 per cent., and the Eastern Extension Company 6 per cent., against 7 per cent. It will be observed that we brought into the past year's accounts £1,949, and carry forward a balance of only £95. We have, in fact, divided our revenue up to the hilt, not even retaining in hand sufficient to meet the expenses of the current half year. Knowing that the interest on the coupons was cumulative, the trustees wished to give the certificate holders as much as possible on account of the April coupon, as they did not see their way to pay the balance of 30s. before October 15th. The expenses of the Trust are £1,359, against £1,349, or only £10 more than last year, in spite of the extra cost of stationery and clerical labour in having to stamp the coupons in the office here—a work which was not necessary when the coupons were paid in full by the bankers. For the current year we estimate that we shall receive at least 1 per cent. from the Anglo-American Company, against 5s. last year, while it is hoped that the Eastern Extension Company will again be in a position to pay a dividend of 7 per cent. In this case, although we shall not be able to pay our coupons in full, we shall give the certificate holders a fair return on their investment. There can be no doubt, gentlemen, that the American cable war of rates must terminate some time; as to when it will terminate I am not prepared to say, but having a strong belief that there is a period when it is positively throwing away money to continue such a war, I hope the termination is perhaps nearer than at present we should be disposed to expect. The reduction of returns, and therefore of dividend, on the part of the Eastern and Eastern Extension Companies arose through very material reductions made in the tariffs at the Berlin Conference. That reduced the income for the moment of these companies by something like £100,000. Of course it takes time to recoup this loss, and temporarily their dividends had to suffer, and consequently we have had to suffer with them. There was a Colonial Conference the other day, in which telegraphs were discussed. The result of that conference is, I think, to leave us in a better and stronger position than we have occupied for a very long time. I am therefore hopeful that before I have the pleasure of seeing you again the traffic will continue to show that vitality which has hitherto been so remarkable in telegraphs, and that we shall be able to go back both in the Eastern and Eastern Extension to our old dividends, and I hope also that the war of rates to which I have referred will be terminated in the interests of the Anglo-American and all concerned. Altogether, I think the prospects are good for those who hold in this Trust, and that we shall before long be in a better financial position than we are in to-day. With these remarks, I beg to move:—"That the report and accounts of the Trustees, now submitted to the meeting, be approved and adopted."

The Right Hon. Viscount MONCK seconded the motion, which was carried unanimously.

The CHAIRMAN: The next resolution is one that rests with the shareholders, and I shall be pleased if any of them will move it.

Dr. HATHAWAY: The resolution which has been put into my hands is: "That Messrs. John G. Griffiths and Mr. John Gane be re-elected auditors of the Trust for the current year, at a remuneration of £25 each," which I beg to move.

Mr. DAVIES seconded the motion, which was agreed to unanimously.

On the motion of Mr. DAVIES, seconded by Dr. HATHAWAY, a vote of thanks to the Chairman and Directors was cordially passed.

The CHAIRMAN: Gentlemen, we are always pleased to have our services recognised by the shareholders on occasions of this kind. We do our very best for your interests, and when that best is appreciated by you it makes us still more earnest to carefully look after your affairs. As I said before, I hope by the time we shall meet you again we shall be able to report a better state of things.

The proceedings then terminated.

West India and Panama Telegraph Company (Limited).

Report of the Directors to be presented to the twentieth ordinary general meeting of members, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, the 18th inst., at 12 o'clock:—

The amount to credit of revenue is £37,930. 18s. 11d., and the expenses have been £27,934. 18s. 5d., leaving a balance of £9,996. 0s. 6d. which, with the balance of £2,292. 13s. 0d. brought from last account, makes a total of £12,288. 13s. 6d. with which it is proposed to deal as follows:—

Payment of 6s. per share on account of arrears of dividend on the first preference shares	£10,368 18 0
Balance to current half year's account	1,919 15 6
	£12,288 13 6

The traffic receipts for the six months show an increase of £147. 12s. 3d. as compared with the corresponding period. The expenses on account of repairs of cables have been exceptionally heavy during the half year, amounting to £4,800 in excess of the corresponding half. Both vessels have been more continuously engaged. The Jamaica-Colon section, referred to in the last report, was repaired on the 24th December after prolonged operations, rendered extremely costly and tedious by the great depth of water and the rocky nature of the sea-bed. The cable was eventually recovered from a depth of 1,613 fathoms. After completing this work the ss. "Grappler" resumed operations on the original (duplicate) Jamaica-Porto Rico section, but had to be recalled in order to proceed with other repairs. The Holland Bay-Ponce cable failed on the 30th ult., but was repaired on the 7th inst. The "Grappler" will now be ordered home, and will return to the West Indies with 250 knots of deep sea cable referred to in the last report.

The attention of the Board has been directed to a proposal which has been submitted to the French Chamber of Deputies by the Minister of Posts and Telegraphs, to authorise the guarantee of a gross revenue of £40,000 per annum for the construction of a cable between Para (Brazils) and New York, touching, among other places, at the French Islands of Martinique and Guadeloupe, which have been connected with the telegraphic systems of the world for the past 16 years by means of this Company's cable. The Directors have addressed communications to the French Government, pointing out the inevitably disastrous financial results of such an undertaking, and the inadequacy of the advantages expected, to justify so large a liability. A final decision has not yet been arrived at.

Of the £50,000 Six per Cent. Debentures which fell due on the 31st December last, £37,900 have been extended for a further term of five years at 5 per cent. per annum. The balance of £12,100 is still for disposal. In accordance with the Articles of Association, Sir James Anderson and William Andrews, Esq., retire at this meeting and offer themselves for re-election. John George Griffiths, Esq., the auditor, also retires and offers himself for re-election.

CITY NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY. — The traffic receipts of this company for the week ended 6th inst. amounted to £4,001.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company for April amounted to £20,320. From January 1 to April 30 they were £81,520, and for the corresponding months in 1886 and 1885 £78,480 and £89,200 respectively.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 6th inst. were £3,322.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th April are £3,156, as compared with £2,467 in the corresponding period of 1886.

NOTICE OF REMOVAL.—The Direct Spanish Telegraph Company inform us that the general offices of this Company have been removed to Winchester House, 50, Old Broad-street, E.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 11.		BUSINESS DONE WEEK ENDING MAY 11. Highest.	Lowest.
Anglo-American	36,	37	37⅞	36
Do. Preferred	58½,	59½	60½	59
Do. Deferred	14½,	15½	15½	14½
Brazilian Submarine	10⅞,	11	10 15-16	10½
Cuba	12,	12½	12⅝	12½
Do. Preference	18,	19	—	—
Direct Spanish	2⅞,	3	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9½	9
Eastern Telegraph	10⅝,	10¾	10¾	10½
Do. 6 per Cent. Preference	13⅞,	14½	14	—
Do. 5 per Cent. Debentures, 1899	108,	109	—	—
Eastern Extension	11⅛,	11⅜	12 1-16	11⅝
German Union	10½,	11	10½	10½
Globe Telegraph and Trust	5⅛,	5⅞	5⅞	5 9-16
Do. Preference	12½,	12⅞	12⅞	12 9-16
Great Northern	13⅜,	13¾	13¾	13¾
Indo-European	84,	85	—	—
Reuter's	7½,	8	7 11-16	7⅞
Submarine	180,	190	134	—
West India and Panama	6,	7	—	—
Do. 1st Preference	9½,	9⅝	9⅝	9½
Western Brazilian	7⅛,	7⅜	7⅜	7 3-16
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅝	—	—
Oriental	3-16,	5-16	—	—
United Telephone	13½,	14	13 11-16	13½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¾,	3¼	3	2¾
Do. (fully paid)	4½,	4⅝	4½	4½
Swan	1⅜,	1½	—	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36,	37	37	36
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23½

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NOTES.

INTERRUPTION OF A FRENCH CABLE.—The cable between Porto-Rico and the Antilles is interrupted.

FIUME.—The port and town of Fiume are to be lit by electricity; power will be obtained from the River Fiumera, at a point some miles from the town.

TUNNEL LIGHTING.—The Hoosac Tunnel, near Boston, U.S., is to be lit throughout by Westinghouse transformers. The tunnel is 5½ miles in length.

CENTRAL LIGHTING STATIONS IN AMERICA.—The number of central electric lighting stations in full operation at the present time in America is given as 426.

WATERFORD.—Messrs. Laing, Wharton and Down have obtained the contract for lighting the streets of this town with arc lamps. The Thomson-Houston system will be employed.

CONTRACT OPEN.—Tenders are being asked for the lighting of the town of Port Louis in the Mauritius; no particular method is stipulated for. Further information may be obtained from the town clerk.

MADRID.—The *Imparcial* states that efforts are being made to arrange for the lighting by electricity of the grounds of the forthcoming Philippine Exhibition at Madrid. An installation of at least 6,000 lights is spoken of.

SHIP LIGHTING.—The North of Scotland and Orkney and Shetland Steam Navigation Company's new steamer, "St. Sunniva," has been fitted with an installation of 136 lamps by Messrs. J. D. F. Andrews and Co., of Glasgow.

"ELECTRO-DEPOSITION."—We have received from Messrs. Crosby Lockwood and Co. a copy of the second and revised edition of the work by Mr. Alexander Watt on "Electro-Deposition: A Practical Treatise on the Electrolysis of Metals, with several chapters on Electro-Metallurgy."

ORDERS FROM INDIA.—The Gülcher Company have, we hear, received orders for three installations for lighting palaces in India. The present order consists of one 100-light installation, and two 500-light installations, with engines, boilers, dynamos, accumulators, and fittings complete.

"THE SPECIALIST SERIES."—We have received from Messrs. Whittaker and Co. a copy of the second edition of the "Specialist Series" volume on "Magneto and Dynamo Electric Machines." This edition contains a preface and an additional chapter on the latest types of machine, by Mr. W. B. Esson.

"THE STORAGE OF ELECTRICAL ENERGY."—We have received from Messrs. Whittaker and Co. a copy of Mr. Bedford Elwell's translation of the collected edition of Gustave Planté's papers, entitled "The Storage of Electrical Energy, and Researches in the Effects created by Currents combining Quantity with High Tension."

"ELEMENTARY PRACTICAL PHYSICS, VOL. II.: ELECTRICITY AND MAGNETISM."—We have received from Messrs. Macmillan and Co. a copy of the second volume of the Owens College series of "Elementary Practical Physics," being the volume on "Electricity and Magnetism," by Prof. Balfour Stewart, F.R.S., and Mr W. W. Haldane Gee, B.Sc.

OPENING OF THE PARIS-HAVRE TELEPHONE LINE.—On Sunday week the telephone line between Paris and Havre was opened for the public service. The distance is about 110 miles. At present communication can only be obtained between the Bourse at Paris and the Central Exchange at Havre. The tariff has been fixed at the rate of 1fr. for five minutes' conversation.

MEXICO.—We learn from the City of Mexico that Commissioners of the State of Zacatecas are travelling in America studying the telephone, telegraph, and electric lighting systems of the large cities there. After inspecting the American cities, the commissioners will sail for Europe for the same purpose. They are generally authorised to examine all inventions and improvements in electrical apparatus.

SLATE CUT-OUT FRAMES AND SWITCH BLOCKS. — Mr. Rashleigh Phipps sends us a sample of his cut-out blocks and covers, made entirely in slate. The advantage, and in many cases the necessity, of using non-inflammable material for the support of fusible cut-outs has long been recognised, and we have seen no material that fulfils the purpose better than slate. These cut-outs are manufactured in all sizes to suit wood casing.

HAMBURG.—The municipality of Hamburg has appointed a committee to consider a proposal for undertaking electric lighting by means of transformers, and in connection with the gasworks it already owns. The capital outlay involved in the scheme under consideration amounts to £50,000. If it is decided to carry out the work the contract will, it is understood, be placed in the hands of Messrs. Schwartzkopf, of Berlin.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The next meeting of this society will be held at 25, Great George-street, S.W., on Thursday, May 26th, at 8 p.m, when a paper on "Underground Telegraphs" will be read by Charles J. Fleetwood, member, followed by the paper on "Driving a Dynamo with a very Short Belt," by Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., which was adjourned from the last meeting.

THE ELECTRIC LIGHT IN THE HOUSES OF PARLIAMENT.—In the House of Commons, in reply to Dr. Tanner, Mr. Plunket (First Commissioner of Works) said that he was deterred by the large expenditure from proposing the adoption of anything like a general system of electric lighting for the House and its offices, but he had directed the preparation of a complete scheme and estimate should the House be disposed to sanction the large expense.

LIGHTING OF THE LYCEUM THEATRE AT EDINBURGH.—The Lyceum Theatre at Edinburgh has been supplied with 200 Victoria lamps of 10 and 17 candle-power, for which current is generated by Victoria dynamos and a Raworth engine. The plant has been erected under the superintendence of Mr. Geipel, district manager of the Anglo-American Brush Corporation. Outside the theatre an arc lamp of 4,000 candle-power is hung, and is run on the same circuit as the incandescents.

PADUA.—The town of Padua supports a telephone exchange which numbers 232 subscribers, and at the low rate of £6 per annum managed last year to pay a 6 per cent. dividend, and carry forward a substantial sum. All the wires are of silicium bronze. The communications in 1886 numbered on the average 738 daily. It appears, however, that the Telephone Company of Milan claim to possess the sole right to the use of the Bell-Blake instruments, and have served a notice to that effect upon the Padua Company.

NARROW ESCAPE OF EDISON.—An American journal says:—"The safe arrival of Mr. T. A. Edison, Mr. E. T. Gilliland, and the other members of their party in this city on May 1st was the occasion of their receiving numerous congratulations over their very narrow escape from drowning on Thursday, 28th April. The entire party of eight persons were standing on a pier at Kissimmee Springs, two miles from Barlow, in Florida, when the pier collapsed and precipitated all the party except

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Mr. Edison and Mrs. Gilliland into the water, which was eight or ten feet deep." Fortunately no lives were lost.

CITY AND GUILDS OF LONDON FINSBURY TECHNICAL COLLEGE "OLD STUDENTS'" ASSOCIATION.—At the last meeting of the Finsbury Technical College "Old Students'" Association, Mr. John Rance, from the Central Institution, read a paper on "Electric Railways." The relative advantages and disadvantages of battery and conductor systems were pointed out, and the efficiency of reversible batteries discussed. The paper concluded with a short description of the various lines now in operation and in process of construction, and tables were given showing the relative cost of electric and horse traction. Altogether the subject was very thoroughly treated, and induced an animated discussion.—At the same meeting Mr. Howard Swan read a short and appropriate paper on "Taking Lecture Notes."

THE TELEGRAPH SERVICE.—In the House of Commons on Tuesday last the Chancellor of the Exchequer, in reply to Sir W. Harcourt, said that the net revenue of the Post Office for the year 1881 was £2,586,436, and the estimated net revenue for the year 1887 was £2,400,000, showing a decrease of £186,000. In 1881 the net revenue from the telegraphs was £413,000. In 1886-7 there would be a deficiency of £223,000, so that in six years there was a falling off in net revenue of £536,000. This was without taking into account the interest on the purchase money of the telegraphs, which was £326,000. If that was added there would be a deficit on the telegraph service for 1886-7 of £549,000. The falling off was due not to diminished receipts, but to the additional expenditure, especially that incident to the parcels post and the introduction of sixpenny telegrams.

ARC LAMPS AT THE NEWCASTLE EXHIBITION.—At the opening of the Newcastle Exhibition on the 11th inst. it was noticed that the arc lamps in the gardens were very unsteady. We understand that this was due to the contractors being late with their work, so that there was no opportunity of regulating the lamps prior to the opening night; in fact, many of the lamps were only hung the same day. As the lamps have been properly regulated they have become perfectly steady, and those in the engine room and north gardens are now burning well, and there is every reason to believe that the installation will be perfectly satisfactory as soon as the contractors have had time to adjust every lamp for its work. Had the installation been completed a week before the opening of the Exhibition the flickering noticed would no doubt have been avoided, and it is certainly unfortunate that this was not done.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The following is the programme of the session of the American Institute of Electrical Engineers, which is being held during the present week:—Papers will be presented on "Storage Batteries," by Mr. E. P. Roberts; "Results with Hard Drawn Copper Wire," by W. Maver, jun.; "Novel Phenomena in Secondary Generator Systems," by Prof. Elihu Thomson; "Installation of Electric Lighting Plants," by Mr. J. A. Powers; "Electric Lighting in Trains," by Mr. J. Wetzler and Mr. T. C. Martin; "Note on the Differing Temperature Coefficients of the Different Coils of a Fine Rheostat," and "Note on the Change from Negative to Positive of the Temperature Coefficients of some Carbon Filaments," both by Prof. W. A. Anthony; and "The Best Ratio of the Section of the Core of the Gramme Armature to the Section of the Field-Magnets," by Mr. D. C. Jackson, of Cornell University.

TEMPORARY INSTALLATION AT BRIDGWATER.—The *Bristol Times and Mirror* of May 16 says: "Upon the occasion of the visit of the Somerset Agricultural Association to Bridgwater last week, very material aid was rendered to the decorations, which were carried out on a large scale, by the use of the electric light. Messrs. King, Mendham and Co., of Bristol, were able at one day's notice to brilliantly light up a portion of the show by means of arc lamps, the dynamo being driven by a portable engine in a yard at some distance from where the lamps were suspended. As was to be expected, the light proved a great attraction to the country visitors, and many came in to the show having seen the glare of the light from a distance of two or more miles. The light was in every way a success, and the manner in which the work was carried out reflects great credit upon the firm, considering the extremely short notice they received at which to undertake it."

THE CALCULATION OF WORK DONE BY AN ALTERNATING E.M.F.—In another column will be found an interesting communication relating to the work done by an alternating E.M.F. in a compound circuit, the numerical data being taken from Messrs. Sharp and Kent's system of regulating series-wound transformers by means of "induction-rings," which we describ d in a recent issue. The calculation affords a good illustration of the immense difference between alternating and continuous E.M.F.'s as regards the energy expended. It is shown, for instance, that in a particular case, while both total current and E.M.F. in the secondary circuit remain constant, the consumption of energy may be caused to vary between 1,000 watts and 6·24 watts. This affords an excellent illustration (and one which should be very beneficial to those electricians who have not yet taken the trouble to make themselves acquainted with the laws of alternating currents) of the necessity for getting rid of the idea that the product E C represents watts when talking of alternating currents. The writer proceeds to show that in the same circuit, if the E.M.F. were continuous instead of alternating, instead of 6·24 watts, work would be done at the rate of 21·5 horse-power.

THE SCHOOL OF ELECTRICAL ENGINEERING AND SUBMARINE TELEGRAPHY.—The managers of this school, Messrs. W. Lant Carpenter and L. Drugman, inform us that they have just received from Mr. H. R. Kempe, of the engineer-in-chief's office, General Post Office, who undertakes the duties of external examiner in electrical engineering, a very satisfactory report on the results of the Easter examination for the vellum certificate of the school. This certificate is granted only to those pupils who get seventy per cent. of the marks, both in the theoretical and in the practical questions, and who have also passed the examination in the course of lectures on mechanical engineering. Certificates were awarded to twelve out of eighteen pupils who presented themselves from the class of the senior instructor, Mr. H. D. Wilkinson. The following is a list of their names and mark percentages:—B. S. Giles, 96·66; H. O. Holford, 96·66; T. D. Clapham, 93·33; W. J. Walters, 90·66; W. A. Purdom, 90; S. H. Lury, 89·33; E. G. Tidd, 88; G. Gregg, 88; F. W. M. Chapman, 87·33; P. J. Pringle, 85·33; A. W. Kingham, 76·66; J. R. Cotton, 74. All these gentlemen passed in electric lighting and transmission of power; three of them, Messrs. Gregg, Purdom, and Tidd, passed also in telegraphy and telephony.

ATTENDING CHURCH BY TELEPHONE.—We learn from a local paper that at the National Telephone Company's offices, Sheffield, last Sunday morning and evening a number of ladies and gentlemen listened to the service held at St. Paul's, Manningham, near Bradford, to which church the telephone wires had been extended. The voluntaries were exceedingly good. The anthem in the morning, "Where withal shall a young man?" by Sir G. J. Elvey, and in the evening the "Motet,"

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"Oh God, when Thou appearest," by Mozart, were most distinctly heard, and the Sheffield audience more than once expressed their high appreciation of the skill of the organist (Mr. J. H. Rooks) and the singing of the choir. The tenor's voice was exceptionally fine. The preacher both morning and evening was the Rev. F. Hill, M.A., Rector of St. Luke's, Miles Platting. At the conclusion of the morning and evening services, Mr. Swithinbank, the company's manager at Huddersfield, and Mr. Young, inspector there, played at their residences several sacred tunes on the piano and harmonium respectively, which were distinctly heard by the audience at Sheffield. Conversation was also carried on in ordinary tones with Manchester, Preston, Burnley, Leeds, Huddersfield, and other towns, and in each case the articulation was as clear as if talking over a local line. Telephone communication between Sheffield, Manchester, Leeds, and other large centres, although not taken so much advantage of in Sheffield as in other towns, will in the near future prove invaluable to the commercial community. Mr. Northam, the Sheffield district manager, was warmly thanked by his congregation for the privileges granted them on Sunday.

COUNTRY HOUSE LIGHTING.—The Gülcher Electric Light and Power Company have completed the lighting of Mr. Neville's country house at Elsted, near Petersfield. The installation, which has been working satisfactorily for some time, has been carried out in the following manner:—The plant consists of a 2 horse-power Spiel petroleum engine, made by Messrs. Shirlaw and Co., of Birminghnm, and drives on to a No. 1 Gülcher shunt-wound dynamo machine. The dynamo charges a battery consisting of 27 Elwell-Parker 15 plate cells. A Mountain improved switch-board is placed by the dynamo machine, and is used for charging and discharging, running the dynamo and accumulators together in case of emergency, or running the lamps direct from the dynamo. A 5-contact switch is also provided on the same slate slab for adding extra cells as the E.M.F. falls, and the volt and ammeters with measuring plugs are arranged so that by inserting or withdrawing a plug the E.M.F. can be measured. The current from the dynamo room is led to the house by a pair of 7-15 cables, made by Messrs. Callender and Co. In the hall special hammered iron brackets have been used, in order to lend themselves to the character of the surroundings. In the bed rooms special raising and falling pendants, designed by Mr. Mountain, are used. Throughout the house the shades are of cut glass. The Gülcher Company adds:—"This installation is, we believe, one of the first where a Spiel petroleum engine has been used for private house lighting, and the result, as far as experience has shown, leads to the conclusion that they are admirably adapted for this purpose, and should be very largely used in the future."

CONVERSAZIONE.—The first *conversazione* of the Royal Society for the season took place last Wednesday evening at Burlington House, when Prof. Stokes (the president) received a numerous and brilliant assembly. The display of scientific apparatus on this occasion was specially interesting. Among physical appliances one which attracted much attention was shown by Prof. Rücker, F.R.S., explaining, by reflection on a screen, the use of Newton's famous rings in testing the expansion of metals by heat. By this beautiful contrivance, which Fizeau has employed, effects can be rendered visible which must be almost infinitesimal in amount. In the adjoining section Mr. C. V. Boys explained a mechanism for shooting threads of glass, emerald, and other substances melted in an oxyhydrogen flame, and attached to an arrow projected from a cross-bow. By this means he drew out filaments of incredible tenuity, quartz for example, so fine that the thinnest parts are beyond the power of any microscope to define. Dr. Marat, F.R.S., had at work in the reading room an instrument for speedy volumetric measurement of carbonic acid, where also Prof. Unwin, F.R.S., exhibited instruments for measuring extensions and compressions in materials subjected to stress to the nicety of the one hundredth thousandth part of an inch. In the principal library Mr. Norman Lockyer displayed a number of interesting photographs of the solar spectra; the Earl of Rosse, sketches of Jupiter and Mars; Prof. Ewing, earthquake records produced by the seismograph; Prof. the Rev. C. Pritchard, F.R.S., star-photographs; and Profs. Ayrton and Perry, the "Secohmmeter." In the department of biology, Mr. Edgar Crookshank, Dr. Klein, and Prof. Marshall Ward showed under the microscope a large number of those micro-organisms which produce disease in men, animals, and plants.

THE ELECTRIC LIGHT IN CHELSEA.—At the meeting of the vestry, on Tuesday, Mr. Mossop, the chairman of the Electric Light Committee, in moving the recommendation of the committee that the offer of the Cadogan Electric Light Company, in which they agree, in the event of the Vestry granting permission for overhead wires, to be bound by all the clauses both of the order and the Act confirming the same, as if the company were the actual holders of the said order and confirming Act, be accepted. This was seconded.—Mr. Kingsbury said he did not think the Vestry could comply with this, when they had for a long time been trying to put down overhead wires.—Mr. Wright said that the Vestry had objected to the Chelsea Electric Supply Company putting up overhead wires, and he did think the Vestry should object to this company putting up overhead wires. It was an impossibility to say that the wires would not break with the snow. He moved that the Vestry do not consent to the overhead wires.—Mr. H. Young said by the decision of the law courts the parochial authorities had not much to do with this question. The Cadogan Company were the same company, he believed, as the Grosvenor Company. The houses built by Messrs. Trollope were fitted with wires, and those gentlemen were connected with this company.—Mr. Mossop said the Cadogan Company wished to place themselves in the same position as the company that had an order, and in that order there was a clause which prevented overhead wires. He thought it was folly for two people to go to one district and compete when there were other parts of Chelsea that were open; but that was nothing to do with the Vestry.—The chairman, in answer to Mr. Wright, said he believed this company asked to be allowed to put themselves under the same terms as if they had been through the form of getting a provisional order.—The amendment was put and lost, and the motion carried.—The committee recommended, with regard to the letter received from the Chelsea Electricity Supply Company, that the Vestry should inform the company that this Vestry will assent to the Board of Trade using its powers under Section 70 of the Provisional Order to suspend the obligations of the company in all streets in Schedule A, save in the following:—Pont-street, Hans-place, Lennox-gardens, Lennox-gardens Mews, Clabon Mews, Cadogan-square, Cadogan-street, Draycott-street, and Draycott-place, for such term of years as they see fit.—Mr. Mossop moved the adoption of the report. This was to allow the company to reduce its area.—Mr. Moon seconded the motion, which was agreed to.

LAUNCH OF AN ELECTRIC YACHT.—The electric yacht, "The Countess," which has been built by Messrs. Lester and Perkins, at the Royal Albert Docks, to the order of the Electric Locomotive and Power Company, was launched on Saturday afternoon last. The boat has been constructed from the designs of Mr. Lester, and is 90ft. in length, 11ft. 6in. in the

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beam, and 5ft. 6in. deep, and will draw about 3ft. of water. The motive power will be supplied by Elieson storage cells, and the screw will be driven by an Elieson motor of the pattern which has already been employed with some success for tramcar traction. The ceremony of christening was performed by the Countess of Galloway as the vessel hung suspended from one of the dock company's huge and powerful derricks. The boat was then swung bodily over the basin, and lowered into the water. The company afterwards adjourned to the workshop, where a light repast had been provided. Mr. T. Wickham proposed "The health of the Countess of Galloway," and spoke of the honour which her ladyship had done them by coming amongst them that day to perform the ceremony of christening the new boat. He felt that that was a ceremony full of promise and fraught with great advantage, not only to themselves, but to the community at large. The vessel they had seen launched that day would combine in itself two very important inventions which their company thought would some day make a very great sensation in the world. In that vessel there would be their new electric motor applying electricity in a new form, and their own accumulator or storage battery, to which they attached very great importance indeed. Therefore in thanking her ladyship for the act she had performed that afternoon, they felt that she had launched and put before the world a scheme which was fraught with great consequences in the future. They felt and hoped that the day was not far distant when not one of Her Majesty's ships or the vessels of the great navigation companies would go to sea without a launch of that kind. In returning thanks on behalf of the Countess, the Earl of Galloway said that had her ladyship not been confident of the success of the scheme they had in hand, he was certain she could not have been persuaded to assist in its development. He also took great interest in the proceedings of the Electric Locomotive and Power Company, but he did not think that vessel would have been built had it not been for the suggestion of Mr. Lester, who was one of the most active of their directors, and who by means of his firm had been instrumental in its construction. Other toasts followed.

Proposed Electric Lighting in Cork.—A special meeting of the Standing Committee of the Cork Corporation was held on Monday week to consider the representations and estimates of Mr. D. O. Bate, of the firm of Messrs. Laing, Wharton and Down, electrical engineers, London, respecting the Thomson-Houston system of electric lighting, with a view of ascertaining if the employment of such a system was practicable and less expensive than the present system of lighting the city by gas. Mr. Bate was called before the committee, and said that since the council meeting had referred him to the committee he had called upon Mr. M'Mullen, the city engineer, who had furnished him with particulars, on which he was able to base somewhat of an estimate as to the number of electric lights required to replace a certain number of gas lights. Approximately, 1,300 lamp posts carried a little over 1,300 jets, and the cost of their maintenance was £4,883. As against that, the corporation could probably profitably utilise 100 arc lights in a number of the streets of the town, leaving the small and crooked streets, which could not be lighted successfully by electricity, to be lighted in the present way. Basing his calculation at £24 per arc, the arcs would cost £2,400 per annum. At the lowest estimate each of these lamps would take the place of six gas jets. That would leave 700 gas jets in the small streets, which would cost, at the same rate, £2,629, and that, added to £2,400, made £5,030, as against £4,883 by the present system of lighting. That was an excess of £147. But in some places he could extinguish ten jets for one electric light, and, making allowance for this additional saving, he found the cost of lighting to be £4,654, £229 less than the cost at present. His esitmates were based on the figures for the year 1885. The city was illuminated by gas, at an average of nine hours per night; and he reckoned for keeping the electric lamps alight for ten hours, the same as his firm usually reckoned for English towns. If the corporation would use oil in the smaller streets, like the Waterford people, they would gain £700 a year. The Lighting Committee of Waterford had accepted the tender of his firm to light the streets of that city for the next five years, and this was now awaiting confirmation by the council. After some discussion it was finally resolved "that Mr. Bate and the engineer select within the channels the sites for 100 electric lamps, Mr. Bate then to furnish an estimate for supplying and maintaining such 100 lights for three or five years; the engineer to ascertain exactly what number of the present gas lamps might be extinguished if those 100 electric lights were erected."—*Gas World.*

Galvanometer Deflection by Alternating Currents.—The interesting and important discovery connected with alternating currents, made by Dr. Fleming in this country (and re-discovered apparently a little later by Prof. Elihu Thomson in America) renders it also interesting to note what was previously known with regard to the use of the galvanometer, with alternating currents. In Dr. Fleming's galvanometer (see *The Electrician*, May 6th) it will be remembered that the suspended needle takes the form of a thin copper disc, and the force by which it is deflected is due to the couple established between the alternating field of the coils and the Foucault currents in the disc, the latter being subject to a retardation due to the time constant of the disc, which has the effect of disturbing the equilibrium between the magnetic effect of the reversals. The fact that a *magnetised* needle is, under certain conditions, deflected in an alternating field was, however, observed by Poggendorff at least as early as the year 1838 (*Pogg. Ann.*, Vol. XIV., p. 353). The phenomenon was named by Poggendorff "Doppelsinnige Ablenkung." Thirty years later, at the meeting of the British Association at Norwich, a paper was read by the Hon. J. W. Strutt (Lord Rayleigh) "On a Permanent Deflection of the Galvanometer Needle by a Rapid Series of Equal and Opposite Induced Currents." This paper was not, however, printed in the *Transactions* of the Association, where the title alone appears. The next mention of the subject which we have been able to find occurs in 1876, when Mr. Chrystal contributed to the December number of the *Phil. Mag.* a paper entitled "Bi- and Uni-Lateral Galvanometer Deflection"; where (following Poggendorff) bi-lateral deflection refers to the deflection of a magnetised needle by alternating currents, which, under certain conditions, may be directed indifferently to either side of zero according to the accident of the first impulse, actual zero being in fact a position of unstable equilibrium. Mr. Chrystal made, however, the discovery that a different effect comes into play when the permanent field in which the needle moves is very strong compared with the alternating field, due to the current in the coils. In this case the equilibrium of the needle while at zero is much more nearly stable than in the previous case; if, however, before the current is started, the needle be moved into any position, either to the right or left of zero, then, on starting the current, it remains deflected upon that side of the scale. Mr. Chrystal enters into a mathematical explanation by which both effects are accounted for. It is, however, clear from what we now know that, owing to the Foucault current effect, the complete theory of the deflection of a magnetised needle must be very complex.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 519, Vol. XVIII.)

ERRATA.—On page 479, Vol. XVIII., the two last lines of the chapter should read as follows:—

The output $\propto \mu \times$ angular velocity $\times$ (linear dimensions) $^{\frac{7}{2}}$

or output $\propto \mu \times$ peripheral velocity $\times$ (linear dimensions) $^{\frac{5}{2}}$

Given the quality of iron we have now the necessary data from which to calculate the value of ρ,

for $$\zeta = Z_2 - Z_1 = \frac{p_1}{\rho};$$

thus $$\rho = \frac{p_1}{Z_2 - Z_1} = \frac{v}{\text{diameter of armature}},$$

v being constant for all sizes of the same type.

After the above value is thoroughly well determined by experiments made with a number of machines, the estimated maximum E.M.F. will afford a means of gauging the comparative magnetic quality of the iron, in which, by bringing this or some equally good test to bear, we may hope in time to get a more strict uniformity.

Returning to our design, we have now to fix upon the cross section of the field-magnets. Knowing the value of Z_2 (making $\sigma_2 = \sigma_1$) we have

$$AB = \frac{Z_2}{18\sigma_2}.$$

In dealing with the length of the cores, we must adopt a similar treatment to that which was employed for the dimensions of the armature, viz., a balance must be struck between the heating effect and the radiating surface.

At first sight this may seem a little difficult, because the conditions are not quite the same as in the armature, where conduction of the heat to other parts of the machine was negligible. A little reflection will, however, show that the ratio between the amounts of heat dissipated respectively from the surface of the magnet bobbin itself and from other surfaces on the frame, &c., is constant for machines of any one type. Thus, having found a coefficient giving good practical results in one case, we may be sure that it will serve for all sizes, having the same general configuration. A point of considerable practical importance arises from the above considerations, and although implicitly contained in the treatment, it will bear emphasis, viz., that the density of current in both armature and magnet winding must necessarily be diminished as the linear dimensions are increased.

For suppose the winding to consist of a single turn of solid copper, the resistance would then be inversely proportional to the linear dimensions, which we will denote by L. Thus $r \propto \frac{1}{L}$. The energy in watts absorbed in this resistance is $w \propto \frac{C^2}{L}$, and by the conditions $\frac{C^2}{L} \propto L^2$ thus $C \propto L^{\frac{3}{2}}$; but if the density were to remain constant C would vary with L^2.

Since in practice magnets have to be wound with wires of various sections in which the coefficient of insulation assumes different values, care must be taken to allow sufficient space for the smallest sizes which are likely to be used. Of course the proposition that the core surface may be used as the basis of calculation for the number of watts converted into heat in any one bobbin only holds good if the ratio between the core radius and the radius to the outside of the winding is kept constant for all sizes. This ratio, we have seen, is subject to modifications in a given size when wound for different purposes, but a constant *average* ratio may very well be maintained. It is now necessary to fix both this average ratio and also a ratio between the heat dissipated and the core surface. For the first, a good proportion will be to make the average depth of winding one-half the core radius, or, if rectangular in section, one-fourth the short diameter. For the second, a maximum of one watt per square inch of core surface will be found a fairly safe rule in general practice. We now have P the exciting power, A B the core section (from which we can also obtain the depth of winding), and a certain ratio in any given case between the length of core and the work done thereon—that is, a given number of watts per linear inch. This gives the sectional area of the wire for series winding, for then the current C flowing in each bobbin is known, and writing d for the depth of winding, w for the watts per linear inch, l for the length of a mean convolution, and A for the copper section, we have

$$\frac{d\,l\,\mu^2}{162 \times 10^4 \,.\, A^2} = \text{resistance} = \frac{w}{C^2},$$

from which A is found. The number of windings n per unit length follow immediately from this equation, and $\frac{P}{2Cn}$ then gives the length of core, the numeric being inserted because there are in general two cores to each magnet.

The length of the iron portions of the magnetic circuit are now known and have been determined in such a way as to secure for them a minimum value; the length of the air gap, δ, has, however, so far only been fixed in a purely arbitrary manner, and we must try to deal with this quantity a little more fully.

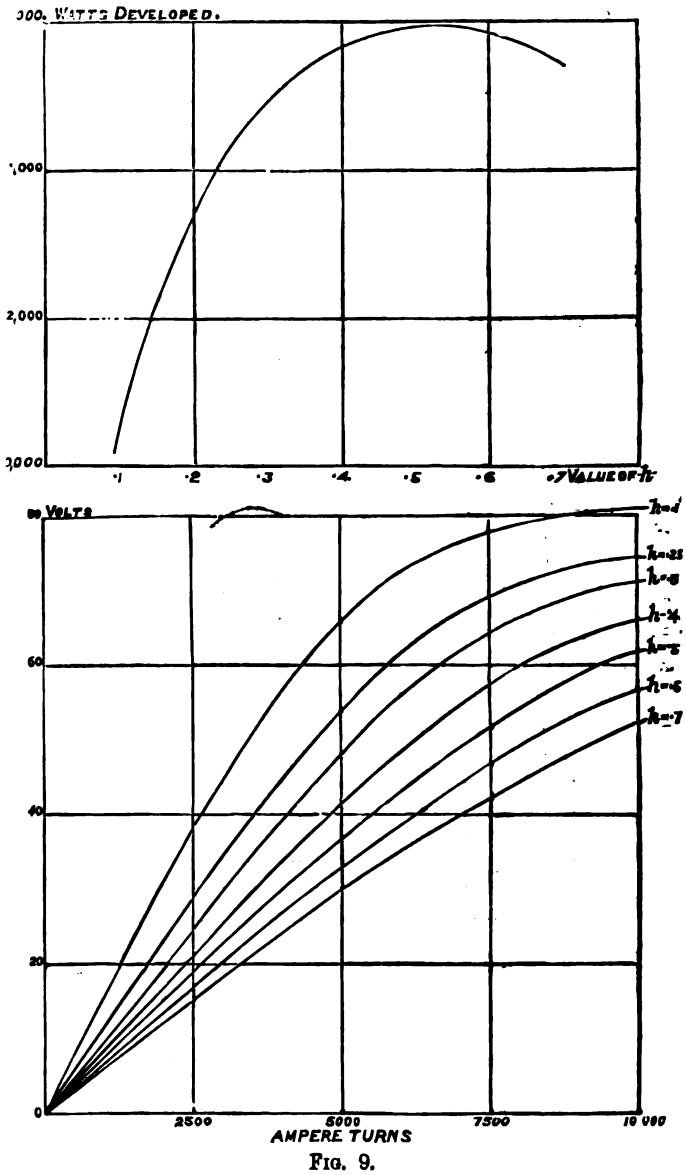

FIG. 9.

It consists of two parts, viz., the depth of winding, which we will call h, and the clearance Q necessary to mechanical safety. What we have now to do is to express the output as a function of h, in order that the effect of modifications in this latter quantity may be traced. As our object is to secure the

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highest efficiency as well as the greatest output, we will cause the two quantities to vary in the same direction by keeping the work done in the armature constant. We then have from equation (2).

$$r_a = \frac{t(a+2\beta)}{\beta(b-\beta)},$$

where

$$t = \frac{N^2}{162 \times 10^4 . \pi \mu^2 P^2 R},$$

$$a = q + p \text{ and } b = 1 - p;$$

thus

$$r_a = \frac{t\left(a + \frac{2h}{R}\right)}{\frac{h}{R}\left(b - \frac{h}{R}\right)}.$$

Also $C = \sqrt{\frac{W}{r_a}}$ where W = watts in armature. We then have

$$C = \left\{\frac{\frac{Wh}{R}\left(b - \frac{h}{R}\right)}{t\left(a + \frac{2h}{R}\right)}\right\}^{\frac{1}{2}}$$

The electromotive force E can also, as we have seen, be expressed in terms of Z, the number of lines passing through the armature core. In this expression Z is a function of h, but as there is also a saturation term, k, which is affected by modifications in h, a general solution of the problem presents serious difficulties. We can, however, take a particular case, and calculate from the tangent formula already given a number of curves of E.M.F. corresponding respectively to certain values of h; a vertical line can then be struck at any suitable exciting value along the line O X, and the points of intersection with the curves will give the E.M.F. in each case. These values will then be taken to form products with the corresponding values of C, and thus another curve of the products of E C may be made in which the various values of h are taken along the line O X. Although such a curve is limited in its actual application to one particular machine, it may yet be taken as *characteristic* of all machines. A case is therefore worked out in Fig. 9 in which the constants are as follows :—

W = 600.
R = 7·625.
t = ·000336.
a = ·8.
b = ·6.
N (number of turns on armature) = 320.
n (revolutions per minute) = 900.
R_A = 1·22.
R_F = 2·85.
ρ (resistance of air leak) = 80.

	for h = ·1	33·7
	„ „ = ·23	45·5
	„ „ = ·3	51·7
Ra =	„ „ = ·4	60·7
	„ „ = ·5	69·6
	„ „ = ·6	78·6
	„ „ = ·7	87·6

SIR WILLIAM THOMSON'S NEW ELECTRIC MEASURING INSTRUMENTS.

Standard Electric Balances.

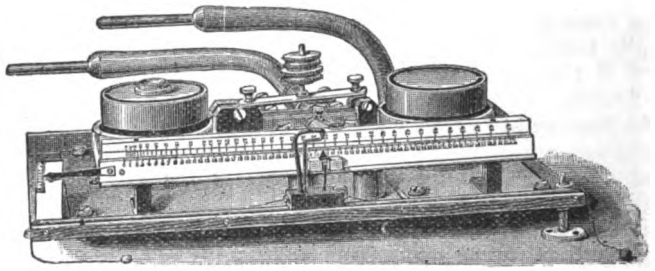
1. These instruments are founded on the mutual forces, discovered by Ampère, between movable and fixed portions of an electric circuit. The shape chosen for the mutually-influencing portions is circular, and each such part will be called for brevity an ampere ring, or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor.

2. In the balance instruments each movable ring is actuated by two fixed rings—all three approximately horizontal. In each of the balance instruments there are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm pulled, one of them up and the other down, by a pair of fixed rings in its neighbourhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In the direct reading voltmeter there is only one fixed ring acting on a single movable ring, which is attached to one end of the balance arm and counterpoised by a weight at the other end.

3. In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

4. In the balance instruments the mid-range position of each movable ring is in the horizontal plane midway or nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted by one of the fixed rings and repelled by the other.

5. In the balances to measure direct currents of from 5 amperes to 1,000 amperes the outer diameter of each pair of fixed rings is somewhat smaller than the inner diameter of the movable ring, and the proportions are so arranged that the force experienced by the movable ring is very nearly constant through half a centimetre on each side of its middle position This is the sighted position for the ordinary use of the balance; and it is marked by the zero line or middle one of five stout black lines across the scale traversed by the pointer of the balance.



Standard Electric Balance.

6. In the balance instruments to measure alternate currents of all strengths, and direct currents of from 5 milliamperes to 10 amperes the fixed rings are larger than in the instruments to measure the larger direct currents. Their outer diameters are greater and their inner diameters less than that of the movable ring which moves between them, above one and below the other. The position of the movable ring equidistant from the two fixed ones is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{2}{10}$ per cent. more than the minimum force.

7. In the balance instruments to measure alternating currents (which may be also used for direct currents) of from 5 amperes to 1,000 amperes the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering, or otherwise from its neighbour, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

8. The balancing is performed by aid of a weight which slides on an approximately horizontal graduated arm attached to the balance; and there is a trough fixed on the right hand end of the balance, into which the proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time (§ 11 below). For the fine adjustment of the zero a small metal flag is provided (as in an ordinary chemical balance) actuated by a fork, with a handle below the case outside as shown in the drawing. To set the zero, the left hand weight is placed with its pointer at the zero of the scale, and the metal flag is turned to one side on the other until it is found that, with no current going through the rings, the balance rests in its sighted position.

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9. To measure a current the left hand weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed white scale (called the inspectional scale) with aid of the finely divided scale, for more minute accuracy, according to the explanations given in § 13 below. Each number on the inspectional scale is twice the square root of the corresponding number on the scale of equal divisions.

10. The slipping of the weight into its proper position is performed by means of a self-releasing pendant hanging from a hook carried by a sliding platform, pulled in the two directions by two silk threads passing through holes to the outside of the enclosure.

11. Three pairs of weights (sliding and counterpoise) in the ratios of 1 : 4 : 16 or 1 : 4 : 25 are supplied with each instrument, adjusted so that each pair gives a round number of amperes, or half amperes or quarter amperes, or of decimal sub-divisions or multiples of these magnitudes of current, on the inspectional scale.

12. The useful range of each instrument is about from 1 to 25 of the smallest current for which its sensibility suffices. The ranges of the different types of this instrument regularly made are—

I.	Centi-ampere balance :	from 2 to 50	centi-amperes.
II.	Deci-ampere	„ „ 1 to 25	deci-amperes.
III.	Ampere	„ „ 1 to 25	amperes.
IV.	Deca-ampere	„ „ 4 to 100	„
V.	Hecto-ampere	„ „ 20 to 500	„

The following table shows for each type of instrument the value per division of the inspectional scale corresponding to each of the three pairs of weights :—

	I. Centi-amperes per division.	II. Centi-amperes per division.	III. Deci-amperes per division.	IV. Amperes per division.	V. Ampere per division.
1st Pair of Weights.	·25	1	1	·5	2·5
2nd „	·50	2	2	1·	5·0
3rd „	1·0	5	5	2·	10·0

13. The fixed inspectional scale shows approximately enough for many purposes the strength of the current; the notches in the top of the aluminium scale show the precise position of the weight corresponding to each of the numbered divisions on the white scale, and practically annul error of parallax due to the position of the eye. When the pointer is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side, to the space between two divisions, may be estimated with considerable accuracy. Thus we may readily read off 34·2 or 34·7 by estimation with little chance of being wrong by one in the decimal place. But when the utmost accuracy is required the reading on the fine scale of equal divisions must be taken, and the strength of current estimated by aid of the table of doubled square roots appended to these instructions. Thus, for example, if the reading is 292 we find 34·18, or say 34·2 as the true scale reading for strength of current; or, again, if the balancing position of the pointer be 301 on the fine scale we find 34·65 as the true reading of the inspectioual scale.

14. The centi-ampere balance, with a thermometer to test the temperature of its ampere rings, and with platinoid resistances up to 2,000 ohms, serves to measure potentials of from 10 volts to 200 volts.

Direct-Reading Vertical-Scale Voltmeter.

15. This instrument is commonly called "engine-room voltmeter," because it can be read at such a distance as across an engine room, and requires for taking a reading no balancing manipulation as in the balance ampere meters. It is convenient not only for engine rooms, but for use in any part of an electric light installation, or in houses supplied with electric light. It shows, by inspection, whether the potential is exactly the proper amount, or, if not exactly so, by what fraction of a per cent., or by what percentage, down to 10 per cent. below or up to 10 per cent. above, it differs from the proper amount.

16. The inspectional voltmeters consist of—

a. A fixed platinoid resistance, in circuit with a fixed and a movable ampere ring.

b. A V-trough rigidly fixed to the movable ring, and carrying the weight proper to the potential to be measured and the temperature of the instrument.

c. A thermometer to show the temperature of the ampere rings.

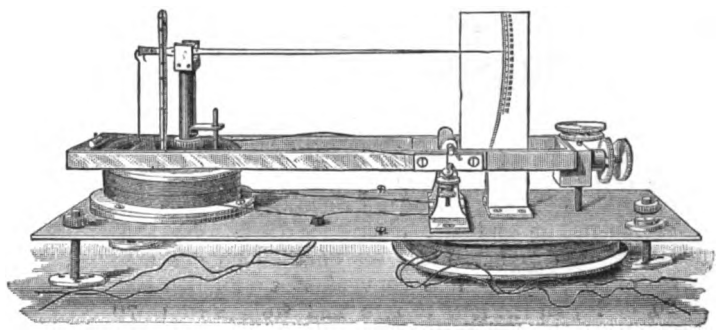
d. A lever, multiplying the motion of the movable ring, and showing the potential to be measured on a vertical graduated scale.

17. The fixed and movable ampere rings are each composed of many turns of fine insulated copper wire, with a total resistance of about 100 ohms. The amount of the added platinoid resistance depends on the potential to be measured in the ordinary use of the instrument. Thus, for example, for potentials of from 10 per cent. below to 10 per cent. above 100 volts, the platinoid resistance is 700 ohms; for potentials of from 10 per cent. below to 10 per cent. above 200 volts, the platinoid resistance is 1,500 ohms.

18. Temperature error is practically annulled in the use of the instrument by simply reading the thermometer (14 *b* and *c*), and seeing that the weight in the trough is the one corresponding to the temperature. Five weights, corresponding to temperatures centigrade of 15°, 20°, 25°, 30°, 35°, are supplied with the instrument in receptacles marked with the temperature, so that no mistake can be made in seeing that it is the right weight that is in use on the instrument at any time.

Marine Voltmeter.

19. The mass of the moving part of the balance voltmeter and engine room voltmeter is too great to be convenient for sea use, and instead a small oblate of soft iron supported on a stretched platinoid wire in the centre of a solenoid of fine copper wire, connected in series with platinoid resistances, variable according to the potential to be measured, serves for marine voltmeter. A pointer carried by the oblate shows, by inspection, direct reading of currents of from 90 to 120 milliamperes. When, as is most commonly the case, the mean potential to be measured is 100 volts, the platinoid resistance is adjusted to make up, along with the fine copper wire solenoid (of which the resistance is about 60 ohms), a total resistance of 1,000 ohms. Thus, the direct reading of potential on scale is in volts.



Engine Room Voltmeter.

20. This instrument is founded on the principle that an oblate spheroid of soft iron, movable round a diameter, tends to turn its equatorial plane parallel to the lines of force in a uniform magnetic field. In the zero position the equatorial plane of the oblate is inclined about 45° to the lines of force of the solenoid, and torsion by the upper and lower parts of the bearing platinoid wire tends to turn it into a position perpendicular to the lines of force. This tendency is balanced by a stop against the needle when no current, or any current not exceeding 90 milliamperes, passes through the solenoid. When a current exceeding 90 milliamperes passes, the torsion couple is balanced by the couple due to the electro-magnetic force.

Adjustable Magneto-Static Current Meter.

21. This instrument has an advantage over the balance instruments, important for some practical purposes, of being available as an accurate direct-reading current meter through a continuous range of from 1 to 90 or 100. Its disadvantages are that it is not available as an alternate current instrument,

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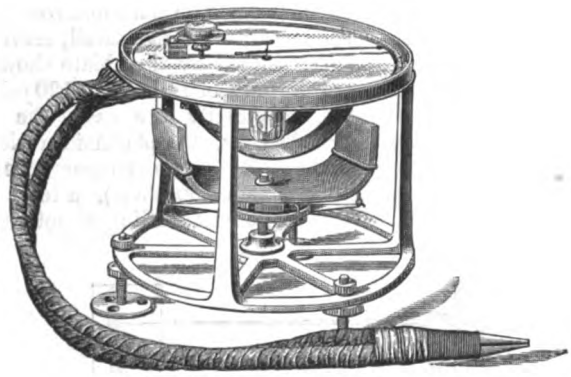
and that the magnetism of the steel directing-magnet does not remain absolutely constant. With good quality of steel, a proper preliminary *ageing* of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism may probably remain exceedingly nearly constant month after month and year after year. Still, it can never be relied upon as absolutely constant. It is therefore necessary to have some means of accurately retesting and readjusting the instrument at any time. This is always easily done with the utmost accuracy if one of the balance ampere meters is available as a standard.

22. When the instrument is used as a lamp counter, primary adjustment or readjustment, at any time, can be performed with great ease, without the aid of any other measuring instrument, by turning the screw platform which bears the adjusting magnet, so as to raise it or lower it until it is found that the deviation from zero produced by the current of any number of lights shows a corresponding number on the scale of the instrument. After each motion of the magnet the zero of course must be readjusted, which can be done either by throwing off all the lamps, or throwing the instrument out of circuit, and then turning the magnet till the needle points to zero. The lower screw must be screwed firmly up to pinch the upper screw when the adjustment is completed. If this is done firmly enough the magnet may at any time, without scruple, be turned round on its platform and brought back again whether for setting the zero, or for any other purpose, as it is only by turning the upper screw that the distance of the magnet from the needle can be altered.



Magneto-Static Current Meter.

23. The scale has 100 divisions, corresponding to equal differences of tangents of the angle between the magnetic axis of the needle and the electro-magnetic axis-vertical of the rings. The divisions may be numbered from 0 to 100; but for many purposes it is convenient to number them from 30, 20, or 10, on the left, to zero, and from zero to 70, 80, or 90 on the right; because we thus have larger divisions in the neighbourhood of the zero than when it is taken at the extreme left of the scale, and because it is sometimes convenient to measure small currents in the direction opposite to that of the currents ordinarily measured. For most purposes probably the numbering 10 left to zero and zero to 90 right will be found most convenient. With scales so numbered any number of lamps from 1 to 90 can be counted by integral numbers of scale divisions. Of course this is not possible to any great accuracy, because the lamps are not all rigorously equal, but the lamp counter serves the important practical purpose of showing at any time the exact number of lamps in use when less than 10 or 15, and nearly enough for practical purposes the exact number however many there are. In private houses it is very useful as a check against some lamp or lamps being left accidentally alight in a cellar or safe-room or other place where the fact of its being alight might escape observation for days or weeks together.

24. To count larger numbers of lamps up to 1,000 or more the instrument is made with smaller rings of more massive conductor. The same proportionate accuracy is attained as with the 100-lamp counter.

Adjustable Resistances or Mho-ohm Drum.

25. This is a combination of platinoid* conductors fulfilling the double object of an ordinary box of resistance coils in series, and a mho box by which a set of conductors can be connected any two or more of them in parallel, so that their conductances† shall be added, instead of the resistances being added, as in the ordinary box of resistance coils.

26. The conductors are coiled anti-inductively,‡ on a drum of thick sheet copper to serve the purpose, not only of bearing them and forming the main support of the instrument, but also of conducting away with great freedom the heat that is generated in each coil through which the current is flowing at any time, and so equalising the temperature of the different coils. A copper sheath is fixed outside in metallic connection with copper partition rings which separate the different coils. This sheath serves the purpose of protecting the coils against damage, and of spreading out the heat generated in each coil over a wide surface freely exposed to the external air, and so greatly diminishing the rise of temperature due to currents through the coils. It is also convenient for the application of a water jacket for laboratory or other purposes in which special care as to the temperature of the coils is needed.

27. All the resistances on the drum are connected in series by permanent solderings. The varying connections for the use of the instrument are made by circular copper cams, mounted on vertical copper shafts, connected by solderings and flexible strands with the soldered joints between the coils in series on the drum. Each shaft is mounted so as to work in two positions, an upper and a lower.

28. For making the mho connections all the shafts are placed in the upper position, and the connections are made by turning the cams so as to press on the outer or inner of two concentric copper rings between which the shafts and cams are mounted.

Explanatory Table for use of Mho-ohm Drum for Resistances.

Distinguishing Letters.	Resistances.
Block. A	1 ohm.
Block. B	2 ,,
Block. C	4 ,,
Block. D	8 ,,
Italic. *a*	16 ,,
Italic. *b*	32 ,,
Italic. *c*	64 ,,
Italic. *d*	128 ,,
Roman. A	256 ,,
Roman. B	512 ,,
Roman. C	1024 ,,
Roman. D	2048 ,,
Roman. E	4096 ,,

Explanatory Table for use of Mho-ohm Drum for Conductances.

Distinguishing Letters.	Conductances.
Roman. E	$\frac{1}{2} \times \frac{1}{2048}$ of a mho.
Roman. D	1 ,, ,,
Roman. C	2 ,, ,,
Roman. B	4 ,, ,,
Roman. A	8 ,, ,,
Italic. *d*	16 ,, ,,
Italic. *c*	32 ,, ,,
Italic. *b*	64 ,, ,,
Italic. *a*	128 ,, ,,
Block. D	256 ,, ,,
Block. C	512 ,, ,,
Block. B	1024 ,, ,,
Block. A	2048 ,, ,,

29. For the ohm connections the shafts are let down to their lower position, and the connections are made by turning the cams so as to short-circuit whichever of the coils are not to be included in the sum of the resistances in series. The working of this part of the plan is precisely the same as in the ordinary resistance-box, except that the short-circuitings are made with easier manipulation by cams with single contacts, instead of by removable plugs with contacts on each side of each plug. This halving of the number of the non-soldered contacts is a serious advantage.

30. In order that the single set of resistances may be available both for the connection in series (for ohms) and for the connection in parallels (for mhos) their proportions must be according to powers of 2 as in ordinary weighing by subdivi-

* When the special purpose is the measurement of the conductivity of copper, the conductors of the mho-ohm drum are made of copper instead of platinoid.

† This is Oliver Heaviside's word.

‡ That is to say, each wire is doubled on itself with the two parts everywhere close together, but well insulated from one another.

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TABLE for facilitating the Addition of Resistances in terms of Ohms on the Mho-ohm Drum.

	A	B	AB	C	AC	BC	ABC	D	AD	BD	ABD	CD	ACD	BCD	ABCD
Saxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Italic	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Roman	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840
+E	4352	4608	4864	5120	5376	5632	5888	6144	6400	6656	6912	7168	7424	7680	7936

TABLE for facilitating the Addition of Conductances in terms of $\frac{1}{2048}$ of a Mho on the Mho-ohm Drum.

	D	C	CD	B	BD	BC	BCD	A	AD	AC	ACD	AB	ABD	ABC	ABCD
Roman	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Italic	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Saxon	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840

Adding E to any combination of the other conductances adds $\frac{1}{2} \times \frac{1}{2048}$ of a Mho to the sum.

sion of the pound into halves, quarters, eighths, sixteenths (or ounces), and half and quarter ounces. Thus when the smallest single resistance on the drum is 1 ohm the other resistances are 2, 4, 8, 16, 32, 64, 128, 256, 512, 1,024, 2,048, and 4,096 ohms, this last being the highest single resistance on the drum as ordinarily made, but higher resistances may be added if desired.

31. The dual system, besides its availability for the two modes of connection, has this advantage, that with it a similar number of coils suffice than in any of the decimal systems of resistance coils ordinarily in use.

BELGIAN ELECTRIC LIGHTING REGULATIONS.

The following regulations for the construction of electric lighting circuits have been issued by the Belgian Postal and Telegraphic Administration :—

1. The lighting circuits shall be entirely metallic, without any earth connections whatever, and connections with water or gas pipes are strictly prohibited.

2. In the case of all portions situated upon State property, or in the neighbourhood of telegraphic or telephonic wires belonging to the State, the conducting wires, if not laid underground, shall be covered with materials which will ensure complete electric insulation, and the whole system must be made impermeable to water.

3. The cables shall be made of sufficient strength to resist any strains to which they may be exposed, and, if necessary, they shall be supported throughout their entire length by wires or metallic cables of the requisite strength, and they shall be placed at a sufficient height to allow the free passage under them of the highest vehicles, and especially of the fire escapes and ladders used for repairing the telegraph and telephone wires.

4. At their points of support on buildings, posts, buttresses, &c., the cables shall be attached in one uniform manner to porcelain insulators, and in such a way that the insulating covering may not be exposed to either mechanical or electrical deteriorations.

5. If bare wires be used for the continuation of cables carried over the places mentioned in Section 1, the bare wire shall not approach within a distance of two metres from any roof or building; it shall be furnished at the points of junction with double insulating covering for a distance of 60 centimeters at least from the supporting insulator, and the junction of the wire to the cable shall be perfectly soldered and insulated.

6. In any places where the direct and return conductors may be near together, or where a dangerous difference of potential may exist, especially in the neighbourhood of the central lighting station, the conductors shall be covered with an additional layer of insulating material; they shall be placed at a distance of not less than two metres from any roof or building, and their distance asunder shall be such as to preclude the possibility of any person touching both of them at the same time.

7. Wherever the lightning conductors cross telegraph or telephone wires, they shall pass underneath the latter at right angles, and at a minimum distance from them of 2 metres. The points of support of these cables shall be at a minimum distance of three metres on one side and the other of the telegraph and telephone wires. To prevent the wires, in the case of breakage, from coming in contact with the electric light conductors, the contractor shall place above each of the latter, along the whole length of the crossing, a metallic wire of sufficient strength

8. The electric lighting conductors and the telephone and telegraph wires shall, as far as possible, not be allowed to run parallel to one another. When this condition cannot be fulfilled the distance between them shall never be less than 12 metres.

9. In conformity with royal decree of the 15th of October, 1876, the contractor shall give to the telegraphic department the preliminary notice prescribed in Section 1 of this decree in the case of any work to be carried out in the neighbourhood of telegraph or telephone lines established or conceded by the Government.

10. The contractor must give a general undertaking to avail himself in his installations of every possible measure recognised by science or by experience as a safeguard.

The installation shall be maintained in the most perfect condition possible, and they shall be tested regularly at least once daily.

11. The contractor shall assume the entire responsibility for all damage or accident arising from his electric light installations.

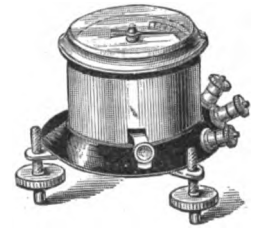
12. The present authorisation is merely permissive; it does not include the right of placing supports upon any buildings or lands belonging to the State, for which a separate authorisation must be obtained in each special case, and it may be revoked at six weeks' notice.

The State reserves to itself the right of making any changes in these regulations, of making new ones, and of demanding at any time that electric lighting conductors, situate on State property, or in the neighbourhood of telegraph or telephone lines established or conceded by the Government, be forthwith removed, without giving any indemnity to the contractor.

13. The installations carried out on State property, and in the neighbourhood of the aforesaid telegraph and telephone wires, may not be modified in the future without special permission from the Government.

NEW PORTABLE HORIZONTAL GALVANOMETER.

This galvanometer, which is illustrated below, has been designed more especially with a view for testing purposes. Its double bobbin is wound with two resistances as in an ordinary detector, and the needle which



swings inside the coils is fitted to a spindle carrying at its upper extremity an agate centre which rests lightly on a delicate needle point, a balanced aluminium pointer being fixed to the spindle just below the cap. By this arrangement a highly sensitive instrument is constituted, and one that is well adapted for testing line circuits, lightning conductor earths, &c. To prevent breakage of the needle point in transit a small lever is so fitted that upon being screwed down the spindle is lifted off its resting place. The scale is carefully engraved on a silvered dial protected by a thick plate glass cover. In using it is only necessary so to place the instrument in the magnetic meridian that the zero is towards the north, and to level it by means of the three levelling screws below the base. This galvanometer has been introduced and is manufactured by Messrs. King, Mendham and Co., of the Western Electrical Works, Bristol.

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THE ELECTRICIAN.

SUBSCRIPTIONS.

The Electrician can be had, by order, from any newsagent, in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—

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THE CANADIAN PACIFIC CABLE ROUTE.

The day when wars and rumours of wars will be things of the past has not come yet, nor is that happy time likely to be known by the present generation. Many of our actions, individual and public, are dictated by the fear of what may be, and are not the result of calm reasoning. The proposed Pacific cable is one of those suggestions, and an attempt is being made to frighten the public into the support of a scheme which has few intrinsic merits to justify its claims to attention or support.

The proposed cable is either a business scheme or purely a political scheme. If the latter, the public must consider the matter as taxpayers; if the former, they must consider it as investors. The promoters seem to have an idea that it is partly a commercial and partly a political question, and that from the latter point of view the Government is to pay a subsidy as a guarantee to the investors against loss. It is singular that no ideas of this character were mooted before the building of the Canadian Pacific Railway. The letter of Mr. Finch Hatton, given in another column, considerably clears the ground, and almost for the first time gives the real reasons why a Pacific cable is being promoted. The development of Canada is a praiseworthy object, against which we have not the faintest objection. The moral, however, of Mr. Finch Hatton's letter is that "Civilisation is a failure" and the "Caucasian is played out." The end of all things is to be war. Our industries are to be developed, not as peaceful industries, but as subsidiary aids in the event of war. No doubt in England we are wrong in imagining that if lines of steamers are wanted in the Pacific, lines of steamers will be provided by some of the long-headed business men who are always on the look out for means of profitably employing their capital. It might have been thought, also, that the Canadian Pacific Railway was promoted by business men for business purposes, and not from any transcendental idea of immediately directing the commerce of Australasia by a new route. We venture to deny that the transshipment and transport of goods across the American Continent will find favour in the eyes of shippers. If the Canadian Pacific Railway is to pay, it will be from the development of the country through which it runs, and for which it provides transport.

It is not so very long since a greater than Mr. Finch Hatton argued that Canada must ultimately, and that ere long, become an integral part of the United States; and it may be asked whether this consummation of American politics is beyond the range of probabilities? If not, would not England be pickling a rod for her own back by subsidising the proposed scheme? Of course, the answer to this is emphatic, that there is no probability of such an event happening, and this answer would come from the very people who act as if the next war of England must of necessity be with a certain other nation and its allies. They claim infallibility in one direction, and no one must doubt the correctness of the views they express, otherwise it might again be objected that *viâ* Egypt was not the only route to the East, and that England has at least two other routes, and could, in a very short time, if necessary, provide a fourth, *viâ* the West of Africa, at a much less expense than by the Pacific.

We have no objection to a Pacific cable if it can be shown that it would pay as a commercial speculation, but we have a great objection to see the English taxpayers asked to contribute to a scheme which cannot pay of itself, and which is promoted solely in the hope of business from it assisting the Canadian Pacific Railway to become a paying concern. The new business opened up by the proposed cable would hardly pay for a repairing ship, and its traffic would mostly consist of traffic diverted from existing cables. In a few words the result of laying a Pacific cable would be largely and needlessly to increase the total capital invested in such means of communication to the districts under discussion—viz, the Australasian Colonies. Income would be taken from existing lines, and thus investors would lose on the one hand without gaining on the other, for it is not and cannot be contended that sufficient business would arise to give a fair return, say of five per cent., upon the total capital invested.

Before touching upon an argument which the promoters of the Pacific scheme have most unaccountably overlooked, it will be well to consider the value of one or two statements in the fourth paragraph of Mr. Finch Hatton's letter. He says that, "Of all lines that could possibly be laid it would be most free from any likelihood of interruption, either from natural causes or from the action of a hostile Power." Here is still seen the dominant idea that only Russia or France, and never can the United States be "a hostile power;" but the unforeseen is often that which happens, and what about likelihood of interruption if the States should be hostile? With regard to natural interruptions we can be more positive, and say emphatically that the Pacific Ocean is just as favourable or unfavourable as any other ocean. How does Mr. Finch Hatton know that the bottom of the Pacific is the most "favourable one possible for prolonging the life of a cable," and how can he speak of great depth as being a protection? We remember the late Dr. Siemens advocated the deep, deep sea for safety of cables, but those who have had greater experience say that an unlevel bottom anywhere is dangerous, and the uncertainty and the cost of repairs increases greatly with the depth. From a business point of view deeply laid cables are a delusion and a snare, the bottom of the sea being as diversified as the surface of the land; and while we may think that the bottom of the Pacific is generally a level, it is

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impossible to believe that a cable can be laid the distance proposed without passing over a number of bad places. These natural difficulties, however, are such as cables have daily to encounter, and we desire only to say that the Pacific presents features no better and no worse than are constantly met with; therefore it presents no special feature to cause it to be preferable to any other route.

With regard to tariffs it may be taken for granted that if the Government sees fit to subsidise the proposed line it will deal completely with the whole question.

It has, we think, been overlooked that the arguments put forward by the promoters of the Pacific cable scheme apply to every other cable. Why should the Pacific cable be subsidised as an alternate route, and the Atlantic cables be left to fight their competitors without State aid? Surely the Atlantic cables are as necessary in the chain as the further link. If the Government is practically to be responsible for the dividend of the new scheme, surely the Government, if the cable is so essential, can borrow the money with less difficulty, at a less cost, and carry out the work themselves. The argument as to the importance of the cable system for imperial purposes leads to the inevitable conclusion that if it is so supremely important the Government should, as in the case of the inland telegraph system, take it over and work it apart from all commercial questions. The fallacy of this conclusion is at once seen, inasmuch as such action would necessitate every Government having its own cable system. It might also be asked whether the subsidisation of a Pacific cable would not rather tend to develop trade in America than with England, and, if so, why should the English taxpayer be asked to support an alternative route to his own commercial disadvantage? A number of other pertinent questions might be asked, but surely enough has been said to show that cables ought to extend more as trade develops new demands, rather than to supply routes which have the sole merit of being alternative. Were it possible to form an international tribunal, the whole cable system would be best worked as an international and unpolitical monopoly. Links here and there in the hands of different companies do not form the best means to get the best results, and were the Pacific cable laid, it would only be one link in the chain, and absolutely at the mercy of some other link.

CORRESPONDENCE.

TELEGRAPH TARIFFS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of 13th inst. you publish the final proposals submitted by Mr. John Pender, the chairman of the Eastern Extension Telegraph Company, to the recent Colonial Conference. I trust that the proposal of the Pacific Telegraph Company, which was also submitted to the Colonial Conference, and which I herewith subjoin, may prove equally interesting to your readers. I have no wish to trespass upon your valuable space by criticising Mr. Pender's proposal and the figures which it contains, for nothing that can be urged in favour of or against the existing system of cables to Australasia and the East has any bearing whatever upon the transcendant importance of establishing telegraphic communication *vid* the Pacific.

If the existing lines of the Eastern Telegraph and Eastern Extension Companies were triplicated throughout it would still leave our communications with the East in their present extremely unsatisfactory state, for there are points of weakness in the Eastern system—such as the transit through Egypt—which nothing could ever render secure. They must inevitably be destroyed in time of war, and in such places ten lines of cables, if they existed, would be just as easy to cut as one.

Everything points to the fact that in the event of war England's military route to the East must be *vid* the Canadian Pacific Railway. It is equally certain that the progress of civilisation will shortly open up the Pacific Ocean as one of the main waterways of the world in time of peace. In order to justify her enormous expenditure on the Canadian Pacific Railway, Canada must extend her communications beyond the terminus at Esquimalt by means of ocean steamers to China, Japan, and Australasia. These liners, while employed as traders and mail carriers in time of peace, could be relied on for transport of troops on the outbreak of war. But without telegraphic communication, of course, it would be impossible to open up the Pacific, either as a highway for commerce or as a military route.

By laying a line of cable as is proposed from Canada to Australia, an alternative means of communication with the East would be established possessing advantages such as no other line could possibly offer. Of all lines that could possibly be laid it would be the most free from any likelihood of interruption, either from natural causes or from the action of a hostile Power. The bottom of the Pacific Ocean is the most favourable one possible for prolonging the life of a cable, while the great depth at which the cable would be laid would be equally efficacious in protecting it, both from the injurious effects of submarine insects and currents, and from the attempts of an enemy's cruisers to cut it.

In conclusion, I would call your readers' attention to the fact that the first proposal to reduce the tariff to Australasia to 4s. per word came from the Pacific Telegraph Company. Further than this, while 4s. a word is fixed as a minimum rate by Mr. John Pender, it is the maximum rate of the Pacific Telegraph Company. Should the estimates of increased traffic be in any way realised, the company will be in a position to effect still further very considerable reductions.—Yours, &c.,

HAROLD FINCH HATTON, Secretary.

Pacific Telegraph Company (Limited),
34, Clements-lane, E.C., 16th May, 1887.

Proposition of the Pacific Telegraph Company (Limited) to the Governments of Great Britain, Canada, and the Australasian Colonies.

1. The Pacific Telegraph Company shall lay a line of cable from Vancouver Island to Australia, touching at Hawaii, Fanning Island, Samoa, Fiji, and New Zealand.

2. The Governments of Great Britain, of Canada, and of the Australasian Colonies shall guarantee to the Pacific Telegraph Company Government traffic to the amount of seventy-five thousand pounds (£75,000) per annum, in such proportions as may be mutually agreed upon by the said Governments.

3. The above guarantee shall date from the completion of telegraphic communication between Canada and Australasia by the company, and shall continue in force for twenty-five years from that date, subject to the following conditions:—

4. In the event of telegraphic communication being interrupted thirty-five days shall be allowed to the company for repairs. If at the expiration of thirty-five days telegraphic communication shall continue to be interrupted, then the guarantee shall be suspended from that date until telegraphic communication be re-established.

5. The rate per word payable by the Governments shall be the current rate charged by the company to the general public, but such rate shall never exceed four shillings per word for the transmission of messages from England to Australasia.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to Mr. Sprague, as far as I understand him, he thinks that electro chemists should not write thermochemical equation in the same way as other chemists, and accuses me of mixing things up because I use symbols in the same sense as nearly all modern chemists. The relation of calories and volts is perfectly understood by both Mr. Fitz-Gerald and myself, and we are in perfect accord as to facts on this point, and we only differ in notation.

Mr. Sprague says I set myself against facts; but he does not say what facts. From the extract quoted by him, it would appear that he thinks that I am wrong either in saying that

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the E.M.F. of cells cannot be measured by the heats of combination, or that the heats of combination are not measures of chemical affinity. But he does not support his assertion.

Mr. Sprague seems to think discrepancies are partly due to the neglect of the heats of solution, &c.; but I at least have been careful not to forget these. He also thinks "the value depends upon the relative values of the volt, ohm, and ampere," and asks, "Will any electrician be good enough to tell us what those units mean? What is their value? and what is the true mechanical equivalent of a 'volt-ampere-ohm-second?'" I am sorry I cannot tell him what a "volt-ampere-ohm-second" is, or what its "dimensions" are, but perhaps that is because I am a chemist.

No one has striven harder than I against the introduction of the "legal" ohm; but Mr. Sprague is wrong in saying it is related to nothing but the erroneously fixed length of a column of mercury, which no one ever made or will make. It is one of the "true units," the decimal multiples of the absolute units for which Mr. Sprague's heart yearns, and that is the reason why it has been brought forward.

Finally, Mr. Sprague goes on to say that "in the present uncertainty of what the various electrical units mean," he reckons one volt = 23,287·7 calories, which, of course, is inaccurate, in spite of the decimal, and says that we should reduce the calories of actions to the equivalent in grammes. I can only repeat that electro-chemists are only a small portion of the community, and that you cannot expect chemists to alter their notation to suit us. In the meantime, H_2O stands for 18 grams of water, and however much we might like to call it 9 grams, we are not at liberty to do so.

Mr. Williams thinks the heats of solution, or of change of physical state, cause the discrepancies between the chemical affinities and the observed heats of combination; but this is not the case. As a striking example the case of salt and snow may be taken. The intense cold is, no doubt, produced by the change in the physical state of the water; but the affinity of salt for water is not nearly enough to account for the phenomenon. If the result were controlled entirely by the chemical affinities, however small, of course the least affinity of salt for water might force the snow to melt; but in other chemical actions the physical states have great influence. For instance, reactions in solutions generally take place so that solid precipitates can be formed.

That such questions as the heats of solutions come in in cells is shown by the higher electromotive force given when strong sulphuric acid is used—that is to say, when the acid has not to be torn away from its water.

As to the last part of Mr. Williams's letter, I think we are very nearly of the same opinion. I do not regard one part of the reaction as being primary and another as a side influence, but look upon them as of equal importance. Mr. Williams and I seem to be practically of the same mind, so the point is perhaps hardly worth discussing. His apt illustration as to lifting the weight seems a very good way of putting such cases.—Yours, &c, JAS. SWINBURNE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Kindly correct an error in my letter last week. The reference to Dr. Ferguson's "Electricity" was printed as from an edition in 1886. I wrote, or meant to write, "edition 1866," and wished to show, by thus citing a little volume on my shelves, that the conception of an "electrolytic thread" was old as well as new.—Yours, &c.,

37, Burlington-road, W. E. ALDRED WILLIAMS.

THE CONSTRUCTION OF DYNAMOS.

TO THF EDITOR OF THE ELECTRICIAN.

SIR: I have been reading Mr. Fricker's articles with very great interest, and if you would oblige me by replying to the following questions I should be grateful. I have been designing a dynamo for fifteen 50-volt 60-watt lamps, on the base of the articles by Mr. C. Hering, entitled "Practical Deductions from Franklin Institute Tests." I took the diameter of armature from mechanical considerations, and then assumed a certain induction (in volts per foot) of active armature wire, which I took to be one-fourth of the whole length of wire on armature; dividing this by distance moved by armature in one second gave induction at one foot per second, and multiplying this by 100,000,000 gave lines per square foot, which divided by 144 gave lines per square inch of polar surface. The magnets I designed from experiments with small machines by a rule of thumb process. Now, I ask you, Sir, would this give reasonable results, or have I got hold of the stick by the wrong end? I must apologise for troubling you so frequently, but I am only able to get information up to date by your journal and the kindness of your contributors.—Yours, &c.,

G. T. PARDOE.

[Our correspondent has, we fear, adopted a procedure which cannot be relied upon to give him consistent results in general application. The diameter of the armature should be looked upon as the corner stone of the design, and the other quantities must be governed thereby. Mr. Fricker's papers show how this may be done in a perfectly general manner. It is not possible to predict the results of a dynamo from the information given by our correspondent, though we should be glad, if possible, to render him any further assistance in our power in the way of explanation.—ED. *E.*]

THE LIGHTING OF TURIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to a notice in your issue of the 22nd of April of a communication from a correspondent at Milan, which, being incorrect as to the facts, is likely to mislead and thus injure this company. I therefore beg you to give publicity to the following rectification:—A contract entered into between this company and the municipality of Turin for the lighting of a part of that city had been transferred by this company to Messrs. Bellani Fréres. When, however, Mr. Gaulard went to Turin to put the installation into working order, he found that the cable, which had been furnished by Messrs. Siemens and Halske, of Berlin, could not support the current for which the secondary generators were designed, the consequence being that the cable burnt. Mr. Gaulard offered to alter the secondary generators to suit a current the cable could support, but finding that Messrs. Bellani, although acting as agents of this company, had already on their premises transformers of Messrs. Zipernowski, Déri et Blatby (whom we consider infringers of our patents, and with whom we have suits pending in different countries), applied first to the municipality to verify by a scientific committee the complete and perfect working of our apparatus under the conditions for which they were constructed.

This inquiry, however, Messrs. Bellani opposed, and the whole question is therefore now being submitted to the law courts.

You will understand from the foregoing how unfair it is to imply that the alleged attempts to light a portion of the city of Turin with the Gaulard-Gibbs system were unsuccessful through any fault in that system, which is now sufficiently proved in many installations which are working perfectly.—Yours, &c., J. E. PICKERING, Sec.

National Company for the Distribution of Electricity by Secondary Generators, May 17, 1887.

SECONDARY BATTERY QUESTIONS IN BELGIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 2 of last week's issue of *The Electrician*, in connection with the above subject, the following remarks occur:—"The use of oxide of lead is certainly open to the public, since it has been shown that M. Planté had employed this method in the course of his researches long before M. Faure had dreamt of his patent." Will your Brussels correspondent kindly oblige by giving the authority from which he quotes the above remarks? For some time hints have been thrown out from reliable quarters as to the validity of the Faure patents. If, as stated, the only claim is the method of attaching and retaining the red lead, there is still some hope for a perfect secondary battery, a thing that does not exist at present. Very little interest is being taken in the improve-

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ment of grids by practical mechanics, as it is generally felt that the present monopoly is valid.—Yours, &c.,

INTERESTED.

ELECTRICAL PHENOMENA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think your correspondent "Leakage" will find that the sparks he refers to have nothing to do with the dynamo at all, but are due to high-tension electricity from the belt. I have frequently drawn sparks from my belt half way between engine and dynamo by holding an iron rule near it, and have been informed by a friend that he has frequently observed the same phenomenon with belts of wood working machinery running at high speed in dry weather.—Yours, &c.,

R. H. C. NEVILE.

Wellingore Hall, Grantham, May 15, 1887.

VOLTS AND CALORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to apologise for supposing that our eminent electricans might be right (after correcting their diatomic blunders) in assuming any reasonable relation to subsist between 23,000 calories and one volt, or, as some prefer to have it, 46,000.

I now find the whole contention to be a flagrant mistake, and for pure lovers of science and common sense, it may be instructive to inquire whether this confusion be not a characteristic effect of the high and abstract methods in which our leaders delight to hide themselves from a common gaze or appreciation.

A *calorie* is a definite amount of heat, resulting from a definite amount of combustion; whereas a *volt* has an indissoluble relation to a current, and is nothing apart from time. One *volt* is the unit of power required to perform unit work in unit time, or, in other words, it is that amount of power which is requisite to drive an ampere of current through an ohm of resistance in one second.

And if this must be compared with calories—an attempt which is probably unwise—then it must be with calories per second, and instead of 46,000, we shall find the volt or volt-ampere relation to subsist with less than one-fourth of a calorie.

If this really be the case, is it worth while to continue these interminable discussions and personal recriminations for a purely mistaken object?

Having investigated this problem from original considerations, I am pleased to find the unexpected issue to be in strict accordance with formulæ previously established by Mr. J. T. Sprague and Mr. D. FitzGerald; but it may assist and encourage some students if we repeat the unfashionable process which does not extend beyond the "Rule of Three." I sought to analyse several batteries (on paper) with different potentials and varying resistances in order to find that one *volt-ampere* invariably means a consumption of 19 grains of zinc or other equivalent per hour, and $19 \div 15{\cdot}43 = 1{\cdot}231365$ grammes per hour, which ÷ by $60 \times 60 = {\cdot}000342$ grammes per second.

I then find that this estimate is strictly confirmed by the recent and very elaborate experiments of Lord Rayleigh and others on the direct electrolysis of copper and silver.

The volt comparison proceeds upon the assumption that if we could find out the number of calories due to an equivalent of zinc when combusted, as in a battery, then this number would represent 1 volt. How such an absurdity could have passed current is amazing to think of.

The direct combustion of zinc = Zn + O (40·5) = 42,500 calories (M. Ditte estimates 44,122). The indirect combustion of zinc in a battery consists of Zn + O = 42,500—Cu + O = 21,885 = 20,615 calories, because for every atom of zinc oxide or sulphate formed there is a corresponding atom of Cu oxide or sulphate decomposed.

These numbers are only approximative, and vary with different authorities; but the *rôle* played by the acid is not fully understood. It is indispensable to dissolve the oxide of zinc as formed; it greatly adds to the conductivity, and in all probability contributes somewhat to the E.M.F. or volt-power. Prof. Silvanus Thompson estimates the total as 23,000, or $46{,}000 \div 2$; Mr. FitzGerald estimates 23,000, and Mr. J. T. Sprague has 23,287 calories.

Now, if we accept this basis, the result easily follows:—

(1) If 32·5 grams : 23,000 calories : ·000342 grams :: ·242 calorie.

(2) If 1 calorie : 3·073 ft.-lb. : ·242 calorie :: ·744 ft.-lb.

and by way of proof or corroboration we next find that 1 volt-ampere = ·2405 gram C heat units = ·737 ft.-lb.

We thus simply deduce the result, that 1 volt of power may be maintained by the expenditure of about ¼ calorie per second.

In *The Electrician*, April 15, 1887, p. 499, Mr. FitzGerald gives some kindred equations in absolute units upon the C.-G.-S. system. What that system is I do not know, nor do I care to know; but he wisely condescends to repeat them in our ordinary or practical units. He says, heat $= \frac{CE\theta}{4{\cdot}2}$ *calories*, also E (power) $= \frac{H \times 4{\cdot}2}{C\theta} =$ *volts*, or $E = \frac{H \times 4{\cdot}2}{96{,}600} = \frac{H}{23{,}000}$ *volts*. All this refinement is doubtless A B C to him, but it is not so to many ordinary students and workers; meanwhile, his $E = \frac{H \times 4{\cdot}2}{C\theta}$ *volts* really implies "that with unit current, in unit time, $\frac{1}{4{\cdot}2}$ calorie is expended for each volt, *i.e.*, about ·24 calorie."

I do not see that a more perfect corroboration could possibly exist; nor is it at all otherwise with Mr. J. T. Sprague, who has entertained the subject in his work on "Electricity" (2nd edition), where he shows that 23,287 calories, *continued* for 97,808 seconds, would equal ·238 calorie per second; which is another way of saying that "with unit current in unit time $\frac{1}{4{\cdot}2}$ calorie is expended for each volt," or, in either case, an expenditure of about ·74 ft.-lb. per second maintains 1 volt.

There is probably a simplicitly and definiteness about volts which is not well approximated by calories, and, if so, why all this furor of mistake to compare the two things? Calories depend so much both on the antecedents and consequents of a given reaction as to render its determination often a matter of great difficulty.

For the enlightenment of Mr. Swinburne it may be well to repeat with emphasis my remark that whenever moderns are impelled or necessitated to appreciate the *real* relations, they invariably do so by a "hocus pocus" arrangement, which virtually conforms to the old or equivalent view of things.

This is evaded by a flippant assumption that the two views are equally true, that mass 9 of water = 34,000, as mass 18 = 68,000; that one is as good and true as the other, but that the latter best suits the views of modern chemistry.

On the contrary, we maintain that the two things are *different*, in the sense, that one is *true*, where the other is fanciful hypothesis. Mr. Shaw and Lord Rayleigh find that *the same electrolysis* which deposits 1 of copper may also deposit 3·4 of silver.

Now *this ratio* is a fact in nature, and in accordance with all other chemical truth; but it necessitates the "hocus pocus" when the atomic weights *are supposed* to be as 63 to 108. It is precisely thus with Mr. Sabine, who found by *observation* a 10 per cent. enlargement of volume; but without the "hocus pocus" he could not have derived the same 10 per cent. from *calculation*.

These, however, are only faint ways of showing the validity of this contention as compared with the overwhelming evidence supplied by the widest assemblage of chemical facts.

Yours, &c., SAMUEL E. PHILLIPS, F.C.S.

NOTE ON THE REGULATION OF SERIES-WOUND TRANSFORMERS BY "INDUCTION-RINGS."

The method of regulating series-wound transformers, described in *The Electrician* of April 29th (in which lamps switched off are replaced by coils whose virtual resistance is equal to that of the lamps), will be found on examination to present some rather curious points. From the practical point

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A circuit containing self-induction acts as if it had a larger resistance than its true one when a current is started in it, and a smaller resistance when the current is stopped. Hence, if balance be obtained with a Wheatstone bridge in the ordinary way, the fact of any of the arms possessing self-induction, or of any one of the arms having a condenser attached to it, will produce no effect on the balance if the battery circuit be rapidly made and broken, provided that the rapidity of make and break be not too great for the currents in the arms of the bridge to reach their steady values each time that the battery circuit is made, and to die away each time that it is broken. If the currents have not time to reach their steady value when the battery circuit is closed, and to die away when it is broken, then self-induction in any one of the arms will produce a disturbance in the balance; but such a method of measuring a coefficient of self-induction would lead to very complicated formulæ, and is not worth developing with the view of obtaining a simple method of measuring self-induction.

It therefore occurred to us to consider whether, without employing such rapid makes and breaks as would prevent the currents reaching their steady values, the self-induction of a circuit might not be made to act as an apparent steady definite increase of the resistance of that circuit which could be measured in the ordinary way with a Wheatstone bridge or differential galvanometer, and by this means the measurement of a coefficient of self-induction would simply resolve itself into the measurement of a resistance. And this problem we solved in the following way, in the spring of 1886:—

The coil, the coefficient of self-induction of which it is desired to measure, is placed in one of the arms of a Wheatstone bridge, the three other arms consisting of ordinary doubly-wound resistance coils possessing no appreciable self-induction, and not only is the battery circuit rapidly made and broken, but, in addition, after each closing of the battery circuit the galvanometer circuit of the bridge is either short-circuited or broken, so as to cut out the galvanometer, and after each breaking of the battery circuit the galvanometer circuit is either unshort-circuited or closed again, so that the galvanometer is now operative again. In this way all the successive impulses of the galvanometer needle that are produced on starting the current in the coil with self-induction produce their *cumulative* effects, but the successive impulses of the needle that, under ordinary circumstances, would be produced on the needle in the opposite direction are cut out. Hence the self-induction possessed by one of the arms causes that arm to apparently increase in resistance by a definite amount depending on the coefficient of self-induction and the number of operations performed per minute. This apparent increase of resistance produces a deflection of the galvanometer which can be noted, and its value ascertained by comparing it with the deflection produced with steady currents when one or more of the arms of the bridge is altered by a known amount, as in making the Rayleigh test described above. But since the necessity of having to read the deflection limits the speed of performing the double make and break operation, in order that the spot of light may not be sent off the scale, we soon replaced this comparative deflection *cumulative* method* by a much more sensitive *zero cumulative* method, and instead of reading the galvanometer deflection we re-establish the balance and bring the needle back to zero, by altering one or more of the arms of the bridge, as in making an ordinary resistance test with a Wheatstone bridge.

In our experiments we have also preferred the periodical short-circuiting of the galvanometer to breaking the galvanometer circuits, since, as there is a current flowing in the galvanometer when this operation is performed if the zero method be employed, the breaking of the galvanometer circuits would produce a spark which would make the calculations difficult, whereas, as will be seen, the periodical short-circuiting of the galvanometer produces an effect that can easily be taken into account in the mathematical investigation.

The measurement of a coefficient of self-induction in this way is extremely simple, because on the condition that the periodic time of our operation is not too short for the currents to become steady in the interval between the closing of the battery circuit and the short-circuiting of the galvanometer, and to die away in the interval between the breaking of the battery circuit and the unshort-circuiting of the galvanometer, we have shown that the following *remarkably simple* formula is very approximately true:—

$$L = T\sigma \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where L is the coefficient of the self-induction of the coil in ohm seconds, or earth quadrants, the commercial unit of self-induction, T the time in any one operation that the galvanometer is non short-circuited while the battery circuit is closed, and σ the apparent increase of resistance of the coil in ohms. It will be observed that when L is small the measured increase of resistance, σ, may be made quite large enough to be accurately measured by making T small. This may be done either by performing the operation rapidly, or, as will be seen later on, by altering the adjustment in the particular apparatus which automatically performs the required operation. *Hence this method is an extremely delicate one for the absolute measurement of a coefficient of self-induction, and the coefficient is expressed in its simplest possible form, namely, as the product of a time into a resistance.*

If instead of periodically cutting out the galvanometer circuit while the battery circuit is being broken, we cut it out while the battery current is being made, and allow the galvanometer to be operative while the battery circuit is being broken, the resistance of the coil possessing self-induction will apparently become less by a definite amount, and in this case σ will be the apparent diminution of its resistance, and T is the time the galvanometer is operative after the battery circuit is broken.

The first apparatus for enabling measurements of self induction to be made in this way was constructed in the spring of 1886, under the superintendence of one of our assistants, Mr. Mather. It consisted of a double commutator, shown in Fig. 1, the spindle S, to which the commutators were locked by the nut N, being rotated at any speed by a small electromotor not shown in the figure, to which was attached a Young speed indicator, which registered the speed of rotation at any moment. The brushes, B_1, B_2, b_1, b_2, were fixed to the baseboard and joined to the bridge, as indicated in the figure. When the double commutator was rotated by the motor (of which the speed was correctly adjusted by means of a Varley flexible carbon-resistance), the portion A B caused the battery circuits to be periodically made and broken, while the other portion, C D, periodically short-circuited and unshort-circuited the galvano-

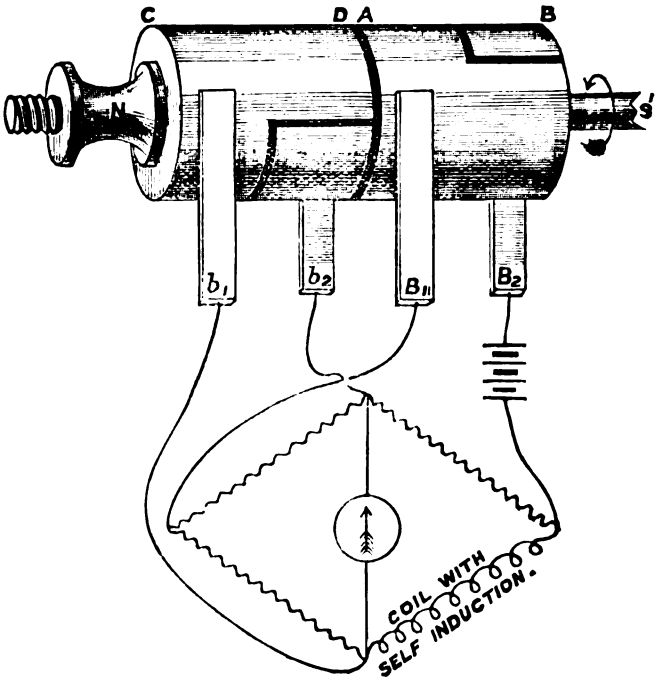

FIG. 1.

meter, so that the following cycle of operation, called for simplicity *one operation*, was performed any desired number of times per minute.

Battery Circuit.	Galvanometer Short Circuit.
Make.	While broken.
While made.	Make.
Break.	While made.
While broken.	Break.
Make.	While broken.

The time T in the formula given above is the interval that elapses in one rotation between the time when the continuous part of the commutator A B comes into contact with the brush B_2, and the time when the continuous part of the commutator C D comes into contact with the brush b_2. This time can be made shorter or longer by varying the speed of rotation, but it can also be varied by loosening the nut, N, and shifting one of the commutators round relatively to the other, and then screwing up the nut again. Indeed, it was for the purpose of enabling this adjustment to be easily made that double springs were in each case employed, instead of making one contact through the spindle.

At about this time—that is, in the summer of last year—we invited Mr. Sumpner, one of the third year students of the Central Institution, to experiment with this apparatus, and generally, by experimenting and by working at the subject mathematically, to find out the capabilities of this new method of measuring self-induction, also to see whether by possibly using the apparatus in some other way the method could be made even still more sensitive. We take this opportunity of thanking Mr. Sumpner for the energetic way in which he has worked at the subject, and for the very large number of experiments on the accuracy of various modes of measuring self-induction which he has conducted, with the occasional aid of two other of the third year students, Messrs. Rossiter and Watney.

* Since this paper was announced to be read, M. Lipmann has communicated to the French Academy a paper "Sur la Détermination du Coefficient du Self-induction," by MM. P. Ledeboer and G. Maneuvrier, describing a new method which these experimenters have devised. An examination of it, however, shows that it is identical with our *less sensitive* 1886 method. After giving some very accurate results that they have obtained by using the new method of testing, they say:—"Nous l'avons préferée d'ailleurs aux autres méthodes pour le mésure des faibles coefficients de self-induction, et notamment à la méthode de M. H. F. Weber (modification de celle de M. Hughes), parce qu'elle conduit à une formule très simple et qu'elle nécessite, en dehors du pont du Wheatstone, d'autre disposatif experimental qu'un interrupteur tournant."

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The various methods of testing which Mr. Sumpner has employed, the mathematical development of the formulæ used by him in each case, and his general conclusions as to the accuracy of the various methods, are given later on in the Appendix; but one interesting result that he has arrived at may here be mentioned, viz., that although the apparatus has during the past twelve months been gradually totally altered in detail, the experiments have shown that the principle originally proposed for carrying out the measurement, requiring the cycle of operations given in the foregoing table to be periodically and rapidly performed, is the simplest and most accurate one to employ. One reason for the accuracy of the method is that neither commutator is in any one of the arms of the bridge, so that no ordinary change in the resistance of the contacts produced by oil or dust, &c., getting in between the springs and the rotary barrels can introduce any error into the test. Of course an actual failure of contact might lead a careless experimenter to a wrong result, but so might a disconnection in the battery or galvanometer circuit in an ordinary Wheatstone bridge, if the conclusion was drawn that, because there was no deflection on pressing down the key, balance had been obtained.

The first thing to be done after constructing the apparatus, was to ascertain what was the formula connecting the unknown coefficient of self-induction with the apparent increase of resistance of the coil, and the time in which the cycle of operations was performed.

This formula we calculated ourselves, neglecting the self-induction of the galvanometer, since we felt that its effect could not be serious. Mr. Sumpner, on the other hand, took up the complete problem, and we give his proof reduced to its simplest form, since, in addition to its application to the experiment in question, the calculation is interesting in connection with the problem of measuring the capacity of a condenser with a Wheatstone bridge and vibrating wippe, which will be found worked out by Clerk-Maxwell, without, however, any notice being there taken of the self-induction of the galvanometer, the effect of which, therefore, on the answer is not considered.

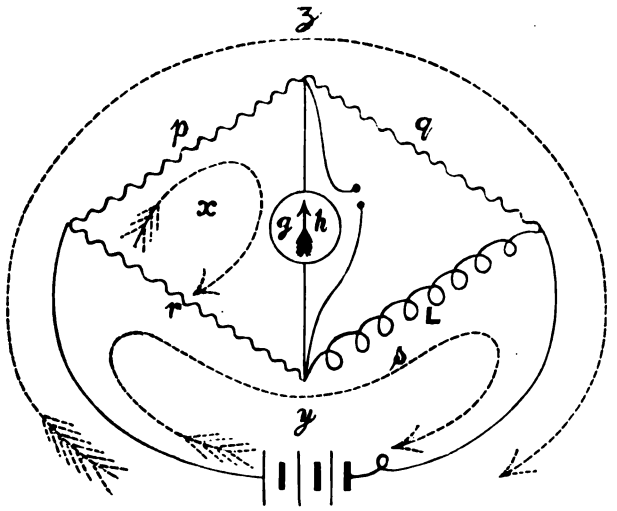

FIG. 2.

Fig. 2. shows the Wheatstone bridge, s being the resistance of a coil with a coefficient of self-induction L; p q and r are the resistances of the three other arms of the bridge when they are so adjusted that there is no deflection of the galvanometer on rotating the commutators at a certain speed. On rotating the commutators a current will sometimes pass one way through the galvanometer and sometimes the other, but with the particular speed of rotation p, q, and r are such that the total quantity passing through the galvanometer is nought. The resistance and coefficient of self-induction of the galvanometer are g and λ, and the electromotive force and resistance of the battery E and b. Then if x, y, z be the imaginary currents on the meshes,*

$$r(x-y)+p(x+z)+gz+\lambda\frac{dx}{dt}=0$$

$$b(y+z)+r(y-x)+sy+L\frac{dy}{dt}=E$$

$$b(y+z)+px\qquad+qz\qquad=E.$$

Eliminating y and z, we have

$$Ax+B\frac{dx}{dt}+P\frac{d^2x}{dt^2}+C\quad=0\quad\ldots\ldots\quad(2)$$

where

$$A=\begin{vmatrix} r+p+g & -r & p \\ -r & s+b+r & b \\ p & b & p+q+b \end{vmatrix}$$

$$B=\lambda\begin{vmatrix} s+b+r & b \\ b & p+q+b \end{vmatrix}+L\begin{vmatrix} p+g+r & p \\ p & p+q+b \end{vmatrix}$$

$$P=(p+q+b)L\lambda,$$

$$C=E(ps-qr).$$

* For the method of solving such problems by the employment of these imaginary currents, see a most interesting paper by Dr. Fleming, in the *Proceedings* of the Physical Society, Vol. VII., p. 215.

Integrating (2) we obtain

$$A\int x\,dt+B\int dx+P\int\frac{d^2x}{dt^2}dt+\int C\,dt=0\quad\ldots\ldots\quad(3)$$

The effect on the galvanometer needle may be divided into two parts—one, the first rush of electricity that occurs through it when the battery circuit is closed during the time the galvanometer is not short-circuited, and the diminution of this current through zero and its increase in the opposite direction until it reaches a certain definite value, when the currents in the arms of the bridge have become steady; the second, the dying away of this reverse current in the galvanometer while it is short-circuited. These two effects we shall consider separately.

To ascertain the amount of the first effect, we must integrate between t equals nought and t equals T, since, by hypothesis, T is the interval that elapses between the closing of the battery circuit and the short-circuiting of the galvanometer.

Integrating between these limits we have

$$\int_0^T x\,dt=Q_1,$$

where Q_1 is the quantity of electricity that flows through the galvanometer in the time T,

$$\int_0^T dx=-\frac{C}{A},$$

since this is the final steady value of the current x, which is nought at time nought.

Also $$\int\frac{d^2x}{dt^2}dt=\frac{dx}{dt}$$

and $$\frac{dx}{dt}=0 \text{ at time T},$$

since, by hypothesis, T is long enough for the currents to become steady. To find the value of $\frac{dx}{dt}$ at time nought, we have the fundamental differential equation for the current through the galvanometer

$$gx+\lambda\frac{dx}{dt}=V,$$

where V is the potential difference at the terminals of the galvanometer at any time. And since where t equals nought x equals nought, we have at time nought

$$\frac{dx}{dt}=\frac{V_0}{\lambda},$$

where V_0 is the value of the potential differential at the terminals of the galvanometer at time nought

and $$V_0=-\frac{Ep}{p+q+b},$$

since at time nought both x and y are nought, therefore at time nought

$$\frac{dx}{dt}=-\frac{Ep}{\lambda(p+q+b)},$$

and therefore $$\int_0^T\frac{d^2x}{dt^2}dt=-\frac{Ep}{\lambda(p+q+b)}.$$

Lastly $$\int_0^T dt=T,$$

therefore equation (3) reduces to

$$AQ_1-B\frac{C}{A}+P\frac{Ep}{\lambda(p+q+b)}+CT=0.$$

Next, let us consider the dying away of the current in the galvanometer after it is short cuited. We may now use simply the equation

$$gx+\lambda\frac{dx}{dt}=0,$$

if the resistance of the short circuit be very small compared with that of the galvanometer itself.

Multiplying by dt, and integrating from t equal T to t equal T', say the time the short circuit is removed, we have

$$gQ_2+\lambda\int dx=0,$$

where Q_2 is the quantity of electricity that passes through the galvanometer while short-circuited. At the moment after short-circuiting

$$x=-\frac{C}{A},$$

the steady value of the current, since the self-induction of the galvanometer prevents any instantaneous change in the current passing through it, and when t equals T' the current in the galvanometer is nought, since, by hypothesis, the time of short-circuiting T' - T is long enough for the current in the galvanometer to die away,

$$\therefore\int_T^{T'}dx=-\left(-\frac{C}{A}\right).$$

Now, in order that there may be no deflection of the galvanometer, we must have

$$Q_1+Q_2=0,$$

$$\therefore\frac{BC}{A_2}-\frac{P}{A}\frac{Ep}{\lambda(p+q+b)}-\frac{C}{A}T=\frac{\lambda}{g}\cdot\frac{C}{A}\quad\ldots\quad(3)$$

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Let σ be the apparent steady increase of the resistance of the coil with self-induction (of which the ordinary resistance is s) produced by the rotation of the commutator at speed corresponding with the times T and T^1, then

$$p(s+\sigma)=rq,$$
$$\therefore C=-Ep\sigma.$$

Substituting this value for C, and for P its value $L\lambda(p+q+b)$ in equation (3), we have

$$L=\sigma\left(T+\frac{\lambda}{g}-\frac{B}{A}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Now $\frac{\lambda}{g}$ and $\frac{B}{A}$ are usually small compared with T, therefore when this is the case

$$L=\sigma T,$$

the simple formula previously referred to.

Referring to Fig. 1, it will be seen if the brushes B_2 and b_2 touch over a small area, and if the centres of these areas are in a plane passing through the axis of rotation, that T is simply equal to

$$\frac{\text{angle between the slits in the two commutators}}{360\times\text{number of revolutions per second.}}$$

We may call

$$\frac{\text{angle between the slits in the two commutators}}{360\text{ deg.}}$$

the lead or l, and l will be equal to $\frac{1}{4}$, for example, when each of the cycle of operations given in the table last for one quarter of a revolution.

Introducing l we have, if σ be in ohms,

$$L=\frac{l}{n}\sigma \text{ second-ohms},$$

where n is the number of revolutions of the commutator per second, or

$$L=\frac{60\,l\sigma}{N}\text{ second-ohms} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where N is the number of revolutions per minute.

A large number of experiments were made in May 1886, with a solenoid of which the resistance was about 4 ohms at ordinary temperatures, to see how nearly the coefficient of self-induction determined by using the double commutator arrangement running at different speeds, and with different leads, agreed with the coefficient of self-induction determined by Lord Rayleigh's method, which gave 0 0215 second-ohm for the solenoid alone, and 0 517 second-ohm when a certain iron core was introduced into the solenoid.

The following are some of the results obtained with the solenoid without the iron core when the lead

$l=\frac{1}{12}$ about :—

N	$s+\sigma$	σ	$L=\frac{60\,l}{N}\sigma$
0	4·06		
660	6·70	2 64	0·0200
760	7·00	2·94	
860	7·50	3·44	0 0200
997	8·00	3·94	
1117	8·50	4 44	
1240	9·00	4·94	
1362	9·50	5·44	0·0200
1450	11·00	6·94	
1850	12·00	7·94	0·0204
2335	13·50	9·44	0 0202

Plotting these results on squared paper, we obtain the curve A A A (Fig. 3), the abscissæ representing the values of N, the number of revolutions per minute, and the ordinates the values of $s+\sigma$, the apparent resistances of the solenoid at the various speeds. This curve we see is a perfectly straight line, which means that the increase of resistance is proportional to the speed ; or, in other words, the approximate formula (5) for calculating L may be employed with *any* of the results, and the value of L so obtained from a few of the results is given in the last column of the preceding table. That we may use the approximate formula at all for L shows us that the term

$$\frac{\lambda}{g}-\frac{B}{A}$$

in the expression (4) is negligible in comparison with T ; and that we may use it even for the result obtained with the highest speed of rotation employed, viz., 2,335 revolutions per minute, shows us that $\frac{1}{12\times2335}$ minute, or about 0 0022 of a second, which is the time the galvanometer remains unshort-circuited after the battery circuit is closed, is long enough for the currents in the bridge to reach their steady value.

The values of the coefficient of self-induction obtained, 0 020, are approximately equal to 0·0215 second-ohm, the value obtained by Lord Rayleigh's method, and that they are not exactly the same arises from the difficulty, already referred to, of estimating the lead l accurately with the eye. This would not introduce any inaccuracy in the actual use of the instruments, since for a given adjustment of the relative positions of the commutators A B and C D in Fig. 1, the value of l is a constant, and this value would be determined once for all, not by the eye, but by an actual experiment made with a coil of known self-induction. We were not, however, calibrating the instrument on the assumption that the approximate formula (5) was true, but using the instrument to see how nearly (5) might be employed. In our experiment l was probably not $\frac{1}{12}$ exactly, but more nearly $\frac{1}{11}$.

Experiments were now made with the lead l, equal about to 0·3.

$l=0·3$ about

N	$s+\sigma$	σ	$L=\frac{60\,l}{N}\sigma$
0	4·06		
770	5·00	0·94	
1120	5·50	1·44	Mean value,
1600	6·00	1·94	0·0218 ohm-second.
2000	6 50	2 44	
2410	7·00	2 94	
2860	7·50	3·44	

These results when plotted give the straight line B B B. Instead, therefore, of calculating the value of L from several of the results, as before, we may more accurately determine it from the point at the end of this line corresponding with a speed of 3,000 revolutions per minute, and an apparent resistance of 7·7 ohms, that is an apparent increase of 3·64 ohms. This gives for L the value 0·0218 second-ohm, also not differing much from the true value 0·0215 second-ohm, considering that the exact value of the lead was not known.

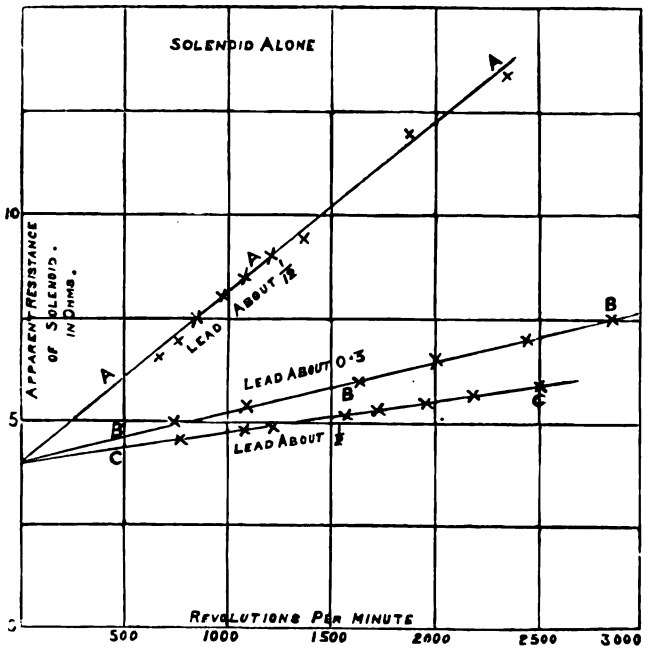

FIG. 3.

Lastly, experiments were made with a lead of about $\frac{1}{2}$, with the following results :—

$l=\frac{1}{2}$ about

N	$s+\sigma$	σ	$L=\frac{60\,l\,\sigma}{N}$
0	4 1		
820	4·7	0 6	0·0219
1100	4 9	0·8	
1240	5·0	1·0	0·0217
1560	5·2	1·1	
1700	5·3	1·2	0·0212
1950	5 5	1·4	
2220	5·7	1·6	0 0216
2500	5·9	1 8	0 0216

Here again the points all lie very nearly in the straight line C C C, and the values given in the last column, calculated from some of the points, are all nearly equal to one another and to the true coefficient of self-induction of the solenoid.

It is clear, therefore, that with speeds up to 3,000 revolutions per minute and higher, and with leads varying from $\frac{1}{12}$ to $\frac{1}{2}$, any single experiment correctly made gives the true value of the self-induction by the use of the simple formula

$$L=\frac{60\,l}{N}\sigma.$$

We see from the formula, and from the experiments which substantiate it, that the smaller the lead and the higher the speed of rotation of the

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commutating arrangement, the larger is the value of apparent increase of resistance—that is, the more sensitive is the test.

The iron core was now inserted in the solenoid, and a series of experiments made with leads equal to $\frac{1}{12}$, $\frac{1}{6}$, $\frac{13}{36}$, $\frac{17}{36}$, in the respective sets of experiments. The results are shown by the curves D D D, E E E, F F F, G G G. It will be observed that, although the speed of rotation of the commutating arrangement did not exceed 680 revolutions per minute, the observations do not lie even approximately in a straight line, until the lead $\frac{17}{36}$ is employed, and even when the last lead $\frac{17}{36}$ is used there is still curvature in the line. This great difference between the curvature of the lines for a range of even slow speeds when the iron core is introduced, and the perfect straightness of the lines beyond the highest speed, 2 800 revolutions per minute, employed with the solenoid alone, arises from the coefficient of self-induction of the solenoid, with the iron core inserted, being about twenty-five times as great as the self-induction of the solenoid alone. Hence the smallest interval, T, between the closing of the battery circuit and the short-circuiting of the galvanometer that can be employed is much larger when the iron core is inserted than when the solenoid alone is used. Consequently the lead must be large or the speed must be slow for the results to lie in a straight line. The curve D D D, obtained with the lead of about $\frac{1}{12}$, is too far from straight for any portion of it to be used in calculating the coefficient of self induction, with the simple formula—in other words, so small a lead was unsuitable to be used. The greater part of the next curve, E E E, is also too far from straight to be used, but the first observation, corresponding with a speed of 156

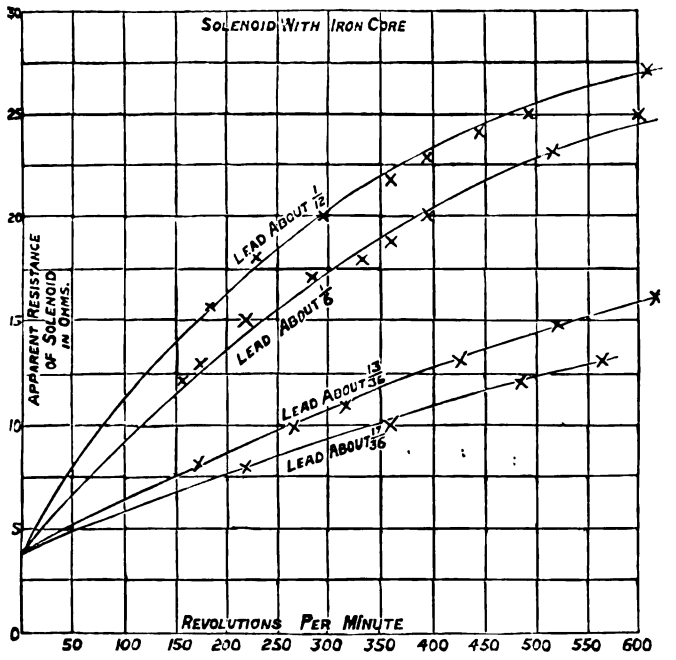

FIG. 4.

revolutions per minute and an apparently increasing resistance of 8 ohms, is on a portion of the curve sufficiently straight to give an answer not much smaller than the truth. The result so obtained is

$$L = \frac{60 \times \frac{1}{6}}{156} \times 8$$

$$= 0{\cdot}513 \text{ second-ohm},$$

which is not very much less than the true value of the coefficient of self-induction of the solenoid with the iron core, as determined by Lord Rayleigh's method, which, as before mentioned, gave 0·517 second-ohm.

With the lead of about $\frac{13}{36}$, the lowest speed at which an observation was taken was 170, corresponding with an apparent increase of resistance of 4 ohms. This gives

$$L = \frac{60 \times 13}{170 \times 36} \times 4$$

$$= 0{\cdot}510.$$

If we take the next speed, 260, corresponding with an increase of resistance of 6 ohms, we find L equal to 0·500.

The last curve G G G, obtained with the largest of the leads, about $\frac{17}{36}$, is the one that, being straightest, will probably give the best results, but as even this is not quite straight we must expect to obtain slightly too low a value. The two first observations correspond with speeds of 220 and 355 revolutions per minute, producing an apparent increase of resistance of 4 and 6 ohms. The values of L obtained from these results are 0·515 and 0·482 second-ohm, from which we should conclude that the true answer was a little higher than 0 515 second-ohm, and this we know is correct, as the true answer is 0·517 second-ohm.

That it is necessary to employ only slow speeds when a large coefficient of self-induction is being measured is no disadvantage, because when the self-induction is large the apparent increase of resistance at even slow speeds is great, and so can be accurately measured.

(To be continued.)

SOCIETY OF TELEGRAPH-ENGINEERS—STUDENTS' MEETING.

The first students' meeting was held in the Society's Library on Thursday, the 5th inst., Prof. W. E. Ayrton, F.R.S., in the chair. Prof. Ayrton briefly addressed the meeting, stating the objects of such meetings, and expressing his warm sympathy with the movement. Mr. J. Rance then opened the discussion upon Dr. Thompson's "Telephonic Investigations," and was followed by Messrs. A. H. Bate, A. C. F. Webb, Wordingham, E. Thomas, and Cooper. Prof. Ayrton replied to several questions, and closed the discussion.

A vote of thanks to Prof. Ayrton terminated a very successful meeting.

COMPANIES' MEETINGS & REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The twenty-seventh ordinary general meeting of shareholders in this Company was held at Winchester House, 50, Old Broad-street, on the 11th inst. under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting, and the minutes of the last general meeting, which were approved by the present meeting and signed by the Chairman.

The CHAIRMAN having stated that that was the twenty-seventh occasion within the last fourteen years upon which his present duty had devolved upon him, continued: It is rather difficult to avoid monotony in discharging this duty on so many successive occasions. However, gentlemen, the monotony has not been altogether of a disagreeable character. I think there have been in the reports and addresses which I have had the honour to make to you elements which have rendered the monotony satisfactory or at least palatable to you. I remember that in the early days of our enterprise our proceedings were somewhat diversified by a not unnatural expression of impatience that our undertaking had not at once realised all the anticipations formed of it. However, that is now a matter of history, for of recent years our proceedings have been tolerably amicable between the Directors and the shareholders, and I think the state of the room on the present occasion proves that the shareholders have no want of confidence in the management of the Directors. Those of you who have taken the trouble to read the present report—which is a condensed history of the transactions of the Company for the last six months—will see that the satisfactory elements to which I have alluded as existing in former reports are not wanting on the present occasion. I am happy to say that we are able to report that all your plant is in excellent condition. We have had during the last six months a complete immunity from any casualty, and our traffic has shown a substantial increase both on the previous half-year and on the corresponding period of the previous year. I may incidentally mention that that satisfactory increase of traffic is still going on, and that up to the present time we are receiving considerably more than we obtained last year. We have been able to pay our usual dividend and to carry a very substantial sum to the reserve fund, and also to carry forward a considerable sum to the current half-year's accounts. Well, under those circumstances I do not think the resolution that I have to propose requires any very great eloquence or argument on my part to enforce it There are one or two incidental circumstances to which I would venture just to allude. We have been threatened with competition in several directions. These threats have not as yet assumed what I may call a tangible form. All I can say about them is that we are exercising the greatest vigilance as to those threatened attacks, and your Board will take such steps in the event of their becoming tangible as they may consider necessary to support the interests of the Company. You are aware that for a long period past we have been engaged in negotiations for strengthening—as I stated on a former occasion—our position in Brazil. Those negotiations have as yet led to no practical result; but we are not without hope that they may do so, and in the meantime we must ask the continued forbearance of the shareholders, for it will be obvious to you that to disclose our hand, and show what our operations are in the midst of a negotiation, would not be a wise or a useful course for us to pursue. I do not think there is any other circumstance that I need allude to, and I beg leave to propose that the report of the Directors and the accounts to the 31st December, 1886, now submitted, be approved and adopted.

Sir JAMES ANDERSON: I beg leave to second that.

The CHAIRMAN, in answer to a question, said that what he had referred to as competition was that there were several proposals to construct new lines which would practically compete with the Company. However, as he had already stated, they had not yet assumed any very decided form. The resolution was then carried unanimously.

On the motion of Mr. GRIFFITH, seconded by Mr. NICOL, a cordial vote of thanks was passed to the Chairman and the Directors.

The CHAIRMAN, in acknowledging the vote, stated that the Directors would continue to do their best, as in the past, to promote the interests of the Company.

The proceedings then terminated.

Submarine Cables Trust.

The sixteenth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the offices of the Trust, Winchester House, No. 50, Old Broad-street, on Wednesday, the 11th inst., Mr. John Pender presiding.

The SECRETARY (Mr. Lewis Wells) read the notice convening the

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meeting, and the minutes of the previous meeting, which were confirmed and signed by the Chairman as correctly entered. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: On referring to the accounts, it will be seen that our revenue for the past financial year amounted to £14,528, against £21,826 in the previous year. As stated in the report, this is mainly owing to the falling off in the dividend paid by the Anglo-American Company, from whom we received only 5s. per cent., against £1. 5s. in 1886; but we have also had diminished returns from our other investments—the Eastern Company has only paid 5½ per cent, against 6 per cent., and the Eastern Extension Company 6 per cent., against 7 per cent. It will be observed that we brought into the past year's accounts £1,949, and carry forward a balance of only £95. We have, in fact, divided our revenue up to the hilt, not even retaining in hand sufficient to meet the expenses of the current half year. Knowing that the interest on the coupons was cumulative, the trustees wished to give the certificate holders as much as possible on account of the April coupon, as they did not see their way to pay the balance of 30s. before October 15th. The expenses of the Trust are £1,359, against £1,349, or only £10 more than last year, in spite of the extra cost of stationery and clerical labour in having to stamp the coupons in the office here—a work which was not necessary when the coupons were paid in full by the bankers. For the current year we estimate that we shall receive at least 1 per cent. from the Anglo-American Company, against 5s. last year, while it is hoped that the Eastern Extension Company will again be in a position to pay a dividend of 7 per cent. In this case, although we shall not be able to pay our coupons in full, we shall give the certificate holders a fair return on their investment. There can be no doubt, gentlemen, that the American cable war of rates must terminate some time; as to when it will terminate I am not prepared to say, but having a strong belief that there is a period when it is positively throwing away money to continue such a war, I hope the termination is perhaps nearer than at present we should be disposed to expect. The reduction of returns, and therefore of dividend, on the part of the Eastern and Eastern Extension Companies arose through very material reductions made in the tariffs at the Berlin Conference. That reduced the income for the moment of these companies by something like £100,000. Of course it takes time to recoup this loss, and temporarily their dividends had to suffer, and consequently we have had to suffer with them. There was a Colonial Conference the other day, in which telegraphs were discussed. The result of that conference is, I think, to leave us in a better and stronger position than we have occupied for a very long time. I am therefore hopeful that before I have the pleasure of seeing you again the traffic will continue to show that vitality which has hitherto been so remarkable in telegraphs, and that we shall be able to go back both in the Eastern and Eastern Extension to our old dividends, and I hope also that the war of rates to which I have referred will be terminated in the interests of the Anglo-American and all concerned. Altogether, I think the prospects are good for those who hold in this Trust, and that we shall before long be in a better financial position than we are in to-day. With these remarks, I beg to move:—"That the report and accounts of the Trustees, now submitted to the meeting, be approved and adopted."

The Right Hon. Viscount MONCK seconded the motion, which was carried unanimously.

The CHAIRMAN: The next resolution is one that rests with the shareholders, and I shall be pleased if any of them will move it.

Dr. HATHAWAY: The resolution which has been put into my hands is: "That Messrs. John G. Griffiths and Mr. John Gane be re-elected auditors of the Trust for the current year, at a remuneration of £25 each," which I beg to move.

Mr. DAVIES seconded the motion, which was agreed to unanimously.

On the motion of Mr. DAVIES, seconded by Dr. HATHAWAY, a vote of thanks to the Chairman and Directors was cordially passed.

The CHAIRMAN: Gentlemen, we are always pleased to have our services recognised by the shareholders on occasions of this kind. We do our very best for your interests, and when that best is appreciated by you it makes us still more earnest to carefully look after your affairs. As I said before, I hope by the time we shall meet you again we shall be able to report a better state of things.

The proceedings then terminated.

West India and Panama Telegraph Company (Limited).

Report of the Directors to be presented to the twentieth ordinary general meeting of members, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, the 18th inst., at 12 o'clock:—

The amount to credit of revenue is £37,930. 18s. 11d., and the expenses have been £27,934. 18s. 5d., leaving a balance of £9,996. 0s. 6d. which, with the balance of £2,292. 13s. 0d. brought from last account, makes a total of £12,288. 13s. 6d. with which it is proposed to deal as follows:—

Payment of 6s. per share on account of arrears of dividend on the first preference shares	£10,368	18	0
Balance to current half year's account	1,919	15	6
	£12,288	13	6

The traffic receipts for the six months show an increase of £147. 12s. 3d. as compared with the corresponding period. The expenses on account of repairs of cables have been exceptionally heavy during the half year, amounting to £4,800 in excess of the corresponding half. Both vessels have been more continuously engaged. The Jamaica-Colon section, referred to in the last report, was repaired on the 24th December after prolonged operations, rendered extremely costly and tedious by the great depth of water and the rocky nature of the sea-bed. The cable was eventually recovered from a depth of 1,613 fathoms. After completing this work the ss. "Grappler" resumed operations on the original (duplicate) Jamaica-Porto Rico section, but had to be recalled in order to proceed with other repairs. The Holland Bay-Ponce cable failed on the 30th ult., but was repaired on the 7th inst. The "Grappler" will now be ordered home, and will return to the West Indies with 250 knots of deep sea cable referred to in the last report.

The attention of the Board has been directed to a proposal which has been submitted to the French Chamber of Deputies by the Minister of Posts and Telegraphs, to authorise the guarantee of a gross revenue of £40,000 per annum for the construction of a cable between Para (Brazils) and New York, touching, among other places, at the French Islands of Martinique and Guadeloupe, which have been connected with the telegraphic systems of the world for the past 16 years by means of this Company's cable. The Directors have addressed communications to the French Government, pointing out the inevitably disastrous financial results of such an undertaking, and the inadequacy of the advantages expected, to justify so large a liability. A final decision has not yet been arrived at.

Of the £50,000 Six per Cent. Debentures which fell due on the 31st December last, £37,900 have been extended for a further term of five years at 5 per cent. per annum. The balance of £12,100 is still for disposal. In accordance with the Articles of Association, Sir James Anderson and William Andrews, Esq., retire at this meeting and offer themselves for re-election. John George Griffiths, Esq., the auditor, also retires and offers himself for re-election.

CITY NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 6th inst. amounted to £4,001.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company for April amounted to £20,320. From January 1 to April 30 they were £81,520, and for the corresponding months in 1886 and 1885 £78,480 and £89,200 respectively.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 6th inst. were £3,322.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th April are £3,156, as compared with £2,467 in the corresponding period of 1886.

NOTICE OF REMOVAL.—The Direct Spanish Telegraph Company inform us that the general offices of this Company have been removed to Winchester House, 50, Old Broad-street, E.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 11.		BUSINESS DONE WEEK ENDING MAY 11. Highest.	Lowest.
Anglo-American	36,	37	37⅞	36
Do. Preferred	58½,	59½	60¼	59
Do. Deferred	14½,	15½	15½	14½
Brazilian Submarine	10⅞,	11	10 15-16	10⅞
Cuba	12,	12½	12⅝	12½
Do. Preference	18,	19	—	—
Direct Spanish	2⅞,	3	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9½	9
Eastern Telegraph	10⅝,	10¾	10¾	10¼
Do. 6 per Cent. Preference	13⅜,	14½	14	—
Do. 5 per Cent. Debentures, 1899	108,	109	—	—
Eastern Extension	11⅛,	11⅜	12 1-16	11⅛
German Union	10½,	11	10½	10½
Globe Telegraph and Trust	5½,	5⅞	5⅞	5 9-16
Do. Preference	12½,	12⅞	12⅞	12 9-16
Great Northern	13⅜,	13¾	13¾	13¾
Indo-European	34,	35	—	—
Reuter's	7½,	8	7 11-16	7⅞
Submarine	180,	190	194	—
West India and Panama	⅝,	¾	—	—
Do. 1st Preference	9½,	9⅝	9⅝	9½
Western Brazilian	7⅛,	7⅜	7⅜	7 3-16
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	—	..
Oriental	3-16,	5-16	—	—
United Telephone	13½,	14	13 11-16	13½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅜,	3½	3	2⅜
Do. (fully paid)	4½,	4⅝	4½	4½
Swan	1⅜,	1⅝	—	—
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36,	37	37	36
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23½

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NOTES.

INTERRUPTION OF A FRENCH CABLE.—The cable between Porto-Rico and the Antilles is interrupted.

FIUME.—The port and town of Fiume are to be lit by electricity; power will be obtained from the River Fiumera, at a point some miles from the town.

TUNNEL LIGHTING.—The Hoosac Tunnel, near Boston, U.S., is to be lit throughout by Westinghouse transformers. The tunnel is 5½ miles in length.

CENTRAL LIGHTING STATIONS IN AMERICA.—The number of central electric lighting stations in full operation at the present time in America is given as 426.

WATERFORD.—Messrs. Laing, Wharton and Down have obtained the contract for lighting the streets of this town with arc lamps. The Thomson-Houston system will be employed.

CONTRACT OPEN.—Tenders are being asked for the lighting of the town of Port Louis in the Mauritius; no particular method is stipulated for. Further information may be obtained from the town clerk.

MADRID.—The *Imparcial* states that efforts are being made to arrange for the lighting by electricity of the grounds of the forthcoming Philippine Exhibition at Madrid. An installation of at least 6,000 lights is spoken of.

SHIP LIGHTING.—The North of Scotland and Orkney and Shetland Steam Navigation Company's new steamer, "St. Sunniva," has been fitted with an installation of 136 lamps by Messrs. J. D. F. Andrews and Co., of Glasgow.

"ELECTRO-DEPOSITION."—We have received from Messrs. Crosby Lockwood and Co. a copy of the second and revised edition of the work by Mr. Alexander Watt on "Electro-Deposition: A Practical Treatise on the Electrolysis of Metals, with several chapters on Electro-Metallurgy."

ORDERS FROM INDIA.—The Gülcher Company have, we hear, received orders for three installations for lighting palaces in India. The present order consists of one 100-light installation, and two 500-light installations, with engines, boilers, dynamos, accumulators, and fittings complete.

"THE SPECIALIST SERIES."—We have received from Messrs. Whittaker and Co. a copy of the second edition of the "Specialist Series" volume on "Magneto and Dynamo Electric Machines." This edition contains a preface and an additional chapter on the latest types of machine, by Mr. W. B. Esson.

"THE STORAGE OF ELECTRICAL ENERGY."—We have received from Messrs. Whittaker and Co. a copy of Mr. Bedford Elwell's translation of the collected edition of Gustave Planté's papers, entitled "The Storage of Electrical Energy, and Researches in the Effects created by Currents combining Quantity with High Tension."

"ELEMENTARY PRACTICAL PHYSICS, VOL. II.: ELECTRICITY AND MAGNETISM."—We have received from Messrs. Macmillan and Co. a copy of the second volume of the Owens College series of "Elementary Practical Physics," being the volume on "Electricity and Magnetism," by Prof. Balfour Stewart, F.R.S., and Mr W. W. Haldane Gee, B.Sc.

OPENING OF THE PARIS-HAVRE TELEPHONE LINE.—On Sunday week the telephone line between Paris and Havre was opened for the public service. The distance is about 110 miles. At present communication can only be obtained between the Bourse at Paris and the Central Exchange at Havre. The tariff has been fixed at the rate of 1fr. for five minutes' conversation.

MEXICO.—We learn from the City of Mexico that Commissioners of the State of Zacatecas are travelling in America studying the telephone, telegraph, and electric lighting systems of the large cities there. After inspecting the American cities, the commissioners will sail for Europe for the same purpose. They are generally authorised to examine all inventions and improvements in electrical apparatus.

SLATE CUT-OUT FRAMES AND SWITCH BLOCKS. — Mr. Rashleigh Phipps sends us a sample of his cut-out blocks and covers, made entirely in slate. The advantage, and in many cases the necessity, of using non-inflammable material for the support of fusible cut-outs has long been recognised, and we have seen no material that fulfils the purpose better than slate. These cut-outs are manufactured in all sizes to suit wood casing.

HAMBURG.—The municipality of Hamburg has appointed a committee to consider a proposal for undertaking electric lighting by means of transformers, and in connection with the gasworks it already owns. The capital outlay involved in the scheme under consideration amounts to £50,000. If it is decided to carry out the work the contract will, it is understood, be placed in the hands of Messrs. Schwartzkopf, of Berlin.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The next meeting of this society will be held at 25, Great George-street, S.W., on Thursday, May 26th, at 8 p.m, when a paper on "Underground Telegraphs" will be read by Charles J. Fleetwood, member, followed by the paper on "Driving a Dynamo with a very Short Belt," by Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., which was adjourned from the last meeting.

THE ELECTRIC LIGHT IN THE HOUSES OF PARLIAMENT.—In the House of Commons, in reply to Dr. Tanner, Mr. Plunket (First Commissioner of Works) said that he was deterred by the large expenditure from proposing the adoption of anything like a general system of electric lighting for the House and its offices, but he had directed the preparation of a complete scheme and estimate should the House be disposed to sanction the large expense.

LIGHTING OF THE LYCEUM THEATRE AT EDINBURGH.—The Lyceum Theatre at Edinburgh has been supplied with 200 Victoria lamps of 10 and 17 candle-power, for which current is generated by Victoria dynamos and a Raworth engine. The plant has been erected under the superintendence of Mr. Geipel, district manager of the Anglo-American Brush Corporation. Outside the theatre an arc lamp of 4,000 candle-power is hung, and is run on the same circuit as the incandescents.

PADUA.—The town of Padua supports a telephone exchange which numbers 232 subscribers, and at the low rate of £6 per annum managed last year to pay a 6 per cent. dividend, and carry forward a substantial sum. All the wires are of silicium bronze. The communications in 1886 numbered on the average 738 daily. It appears, however, that the Telephone Company of Milan claim to possess the sole right to the use of the Bell-Blake instruments, and have served a notice to that effect upon the Padua Company.

NARROW ESCAPE OF EDISON.—An American journal says:—"The safe arrival of Mr. T. A. Edison, Mr. E. T. Gilliland, and the other members of their party in this city on May 1st was the occasion of their receiving numerous congratulations over their very narrow escape from drowning on Thursday, 28th April. The entire party of eight persons were standing on a pier at Kissimmee Springs, two miles from Barlow, in Florida, when the pier collapsed and precipitated all the party except

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Mr. Edison and Mrs. Gilliland into the water, which was eight or ten feet deep." Fortunately no lives were lost.

CITY AND GUILDS OF LONDON FINSBURY TECHNICAL COLLEGE "OLD STUDENTS'" ASSOCIATION.—At the last meeting of the Finsbury Technical College "Old Students'" Association, Mr. John Rance, from the Central Institution, read a paper on "Electric Railways." The relative advantages and disadvantages of battery and conductor systems were pointed out, and the efficiency of reversible batteries discussed. The paper concluded with a short description of the various lines now in operation and in process of construction, and tables were given showing the relative cost of electric and horse traction. Altogether the subject was very thoroughly treated, and induced an animated discussion.—At the same meeting Mr. Howard Swan read a short and appropriate paper on "Taking Lecture Notes."

THE TELEGRAPH SERVICE.—In the House of Commons on Tuesday last the Chancellor of the Exchequer, in reply to Sir W. Harcourt, said that the net revenue of the Post Office for the year 1881 was £2,586,436, and the estimated net revenue for the year 1887 was £2,400,000, showing a decrease of £186,000. In 1881 the net revenue from the telegraphs was £413,000. In 1886-7 there would be a deficiency of £223,000, so that in six years there was a falling off in net revenue of £536,000. This was without taking into account the interest on the purchase money of the telegraphs, which was £326,000. If that was added there would be a deficit on the telegraph service for 1886-7 of £549,000. The falling off was due not to diminished receipts, but to the additional expenditure, especially that incident to the parcels post and the introduction of sixpenny telegrams.

ARC LAMPS AT THE NEWCASTLE EXHIBITION.—At the opening of the Newcastle Exhibition on the 11th inst. it was noticed that the arc lamps in the gardens were very unsteady. We understand that this was due to the contractors being late with their work, so that there was no opportunity of regulating the lamps prior to the opening night; in fact, many of the lamps were only hung the same day. As the lamps have been properly regulated they have become perfectly steady, and those in the engine room and north gardens are now burning well, and there is every reason to believe that the installation will be perfectly satisfactory as soon as the contractors have had time to adjust every lamp for its work. Had the installation been completed a week before the opening of the Exhibition the flickering noticed would no doubt have been avoided, and it is certainly unfortunate that this was not done.

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The following is the programme of the session of the American Institute of Electrical Engineers, which is being held during the present week:—Papers will be presented on "Storage Batteries," by Mr. E. P. Roberts; "Results with Hard Drawn Copper Wire," by W. Maver, jun.; "Novel Phenomena in Secondary Generator Systems," by Prof. Elihu Thomson; "Installation of Electric Lighting Plants," by Mr. J. A. Powers; "Electric Lighting in Trains," by Mr. J. Wetzler and Mr. T. C. Martin; "Note on the Differing Temperature Coefficients of the Different Coils of a Fine Rheostat," and "Note on the Change from Negative to Positive of the Temperature Coefficients of some Carbon Filaments," both by Prof. W. A. Anthony; and "The Best Ratio of the Section of the Core of the Gramme Armature to the Section of the Field-Magnets," by Mr. D. C. Jackson, of Cornell University.

TEMPORARY INSTALLATION AT BRIDGWATER.—The *Bristol Times and Mirror* of May 16 says: "Upon the occasion of the visit of the Somerset Agricultural Association to Bridgwater last week, very material aid was rendered to the decorations, which were carried out on a large scale, by the use of the electric light. Messrs. King, Mendham and Co., of Bristol, were able at one day's notice to brilliantly light up a portion of the show by means of arc lamps, the dynamo being driven by a portable engine in a yard at some distance from where the lamps were suspended. As was to be expected, the light proved a great attraction to the country visitors, and many came in to the show having seen the glare of the light from a distance of two or more miles. The light was in every way a success, and the manner in which the work was carried out reflects great credit upon the firm, considering the extremely short notice they received at which to undertake it."

THE CALCULATION OF WORK DONE BY AN ALTERNATING E.M.F.—In another column will be found an interesting communication relating to the work done by an alternating E.M.F. in a compound circuit, the numerical data being taken from Messrs. Sharp and Kent's system of regulating series-wound transformers by means of "induction-rings," which we describ d in a recent issue. The calculation affords a good illustration of the immense difference between alternating and continuous E.M.F.'s as regards the energy expended. It is shown, for instance, that in a particular case, while both total current and E.M.F. in the secondary circuit remain constant, the consumption of energy may be caused to vary between 1,000 watts and 6·24 watts. This affords an excellent illustration (and one which should be very beneficial to those electricians who have not yet taken the trouble to make themselves acquainted with the laws of alternating currents) of the necessity for getting rid of the idea that the product E C represents watts when talking of alternating currents. The writer proceeds to show that in the same circuit, if the E.M.F. were continuous instead of alternating, instead of 6·24 watts, work would be done at the rate of 21·5 horse-power.

THE SCHOOL OF ELECTRICAL ENGINEERING AND SUBMARINE TELEGRAPHY.—The managers of this school, Messrs. W. Lant Carpenter and L. Drugman, inform us that they have just received from Mr. H. R. Kempe, of the engineer-in-chief's office, General Post Office, who undertakes the duties of external examiner in electrical engineering, a very satisfactory report on the results of the Easter examination for the vellum certificate of the school. This certificate is granted only to those pupils who get seventy per cent. of the marks, both in the theoretical and in the practical questions, and who have also passed the examination in the course of lectures on mechanical engineering. Certificates were awarded to twelve out of eighteen pupils who presented themselves from the class of the senior instructor, Mr. H. D. Wilkinson. The following is a list of their names and mark percentages:—B. S. Giles, 96·66; H. O. Holford, 96·66; T. D. Clapham, 93·33; W. J. Walters, 90·66; W. A. Purdom, 90; S. H. Lury, 89·33; E. G. Tidd, 88; G. Gregg, 88; F. W. M. Chapman, 87·33; P. J. Pringle, 85·33; A. W. Kingham, 76·66; J. R. Cotton, 74. All these gentlemen passed in electric lighting and transmission of power; three of them, Messrs. Gregg, Purdom, and Tidd, passed also in telegraphy and telephony.

ATTENDING CHURCH BY TELEPHONE.—We learn from a local paper that at the National Telephone Company's offices, Sheffield, last Sunday morning and evening a number of ladies and gentlemen listened to the service held at St. Paul's, Manningham, near Bradford, to which church the telephone wires had been extended. The voluntaries were exceedingly good. The anthem in the morning, "Where withal shall a young man?" by Sir G. J. Elvey, and in the evening the "Motet,"

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"Oh God, when Thou appearest," by Mozart, were most distinctly heard, and the Sheffield audience more than once expressed their high appreciation of the skill of the organist (Mr. J. H. Rooks) and the singing of the choir. The tenor's voice was exceptionally fine. The preacher both morning and evening was the Rev. F. Hill, M.A., Rector of St. Luke's, Miles Platting. At the conclusion of the morning and evening services, Mr. Swithinbank, the company's manager at Huddersfield, and Mr. Young, inspector there, played at their residences several sacred tunes on the piano and harmonium respectively, which were distinctly heard by the audience at Sheffield. Conversation was also carried on in ordinary tones with Manchester, Preston, Burnley, Leeds, Huddersfield, and other towns, and in each case the articulation was as clear as if talking over a local line. Telephone communication between Sheffield, Manchester, Leeds, and other large centres, although not taken so much advantage of in Sheffield as in other towns, will in the near future prove invaluable to the commercial community. Mr. Northam, the Sheffield district manager, was warmly thanked by his congregation for the privileges granted them on Sunday.

COUNTRY HOUSE LIGHTING.—The Gülcher Electric Light and Power Company have completed the lighting of Mr. Neville's country house at Elsted, near Petersfield. The installation, which has been working satisfactorily for some time, has been carried out in the following manner:—The plant consists of a 2 horse-power Spiel petroleum engine, made by Messrs. Shirlaw and Co., of Birminghnm, and drives on to a No. 1 Gülcher shunt-wound dynamo machine. The dynamo charges a battery consisting of 27 Elwell-Parker 15 plate cells. A Mountain improved switch-board is placed by the dynamo machine, and is used for charging and discharging, running the dynamo and accumulators together in case of emergency, or running the lamps direct from the dynamo. A 5-contact switch is also provided on the same slate slab for adding extra cells as the E.M.F. falls, and the volt and ammeters with measuring plugs are arranged so that by inserting or withdrawing a plug the E.M.F. can be measured. The current from the dynamo room is led to the house by a pair of 7-15 cables, made by Messrs. Callender and Co. In the hall special hammered iron brackets have been used, in order to lend themselves to the character of the surroundings. In the bed rooms special raising and falling pendants, designed by Mr. Mountain, are used. Throughout the house the shades are of cut glass. The Gülcher Company adds:—"This installation is, we believe, one of the first where a Spiel petroleum engine has been used for private house lighting, and the result, as far as experience has shown, leads to the conclusion that they are admirably adapted for this purpose, and should be very largely used in the future."

CONVERSAZIONE.—The first *conversazione* of the Royal Society for the season took place last Wednesday evening at Burlington House, when Prof. Stokes (the president) received a numerous and brilliant assembly. The display of scientific apparatus on this occasion was specially interesting. Among physical appliances one which attracted much attention was shown by Prof. Rücker, F.R.S., explaining, by reflection on a screen, the use of Newton's famous rings in testing the expansion of metals by heat. By this beautiful contrivance, which Fizeau has employed, effects can be rendered visible which must be almost infinitesimal in amount. In the adjoining section Mr. C. V. Boys explained a mechanism for shooting threads of glass, emerald, and other substances melted in an oxyhydrogen flame, and attached to an arrow projected from a cross-bow. By this means he drew out filaments of incredible tenuity, quartz for example, so fine that the thinnest parts are beyond the power of any microscope to define. Dr. Marat, F.R.S., had at work in the reading room an instrument for speedy volumetric measurement of carbonic acid, where also Prof. Unwin, F.R.S., exhibited instruments for measuring extensions and compressions in materials subjected to stress to the nicety of the one hundredth thousandth part of an inch. In the principal library Mr. Norman Lockyer displayed a number of interesting photographs of the solar spectra; the Earl of Rosse, sketches of Jupiter and Mars; Prof. Ewing, earthquake records produced by the seismograph; Prof. the Rev. C. Pritchard, F.R.S., star-photographs; and Profs. Ayrton and Perry, the "Secohmmeter." In the department of biology, Mr. Edgar Crookshank, Dr. Klein, and Prof. Marshall Ward showed under the microscope a large number of those micro-organisms which produce disease in men, animals, and plants.

THE ELECTRIC LIGHT IN CHELSEA.—At the meeting of the vestry, on Tuesday, Mr. Mossop, the chairman of the Electric Light Committee, in moving the recommendation of the committee that the offer of the Cadogan Electric Light Company, in which they agree, in the event of the Vestry granting permission for overhead wires, to be bound by all the clauses both of the order and the Act confirming the same, as if the company were the actual holders of the said order and confirming Act, be accepted. This was seconded.—Mr. Kingsbury said he did not think the Vestry could comply with this, when they had for a long time been trying to put down overhead wires.—Mr. Wright said that the Vestry had objected to the Chelsea Electric Supply Company putting up overhead wires, and he did think the Vestry should object to this company putting up overhead wires. It was an impossibility to say that the wires would not break with the snow. He moved that the Vestry do not consent to the overhead wires.—Mr. H. Young said by the decision of the law courts the parochial authorities had not much to do with this question. The Cadogan Company were the same company, he believed, as the Grosvenor Company. The houses built by Messrs. Trollope were fitted with wires, and those gentlemen were connected with this company.—Mr. Mossop said the Cadogan Company wished to place themselves in the same position as the company that had an order, and in that order there was a clause which prevented overhead wires. He thought it was folly for two people to go to one district and compete when there were other parts of Chelsea that were open; but that was nothing to do with the Vestry.—The chairman, in answer to Mr. Wright, said he believed this company asked to be allowed to put themselves under the same terms as if they had been through the form of getting a provisional order.—The amendment was put and lost, and the motion carried.—The committee recommended, with regard to the letter received from the Chelsea Electricity Supply Company, that the Vestry should inform the company that this Vestry will assent to the Board of Trade using its powers under Section 70 of the Provisional Order to suspend the obligations of the company in all streets in Schedule A, save in the following:—Pont-street, Hans-place, Lennox-gardens, Lennox-gardens Mews, Clabon Mews, Cadogan-square, Cadogan-street, Draycott-street, and Draycott-place, for such term of years as they see fit.—Mr. Mossop moved the adoption of the report. This was to allow the company to reduce its area.—Mr. Moon seconded the motion, which was agreed to.

LAUNCH OF AN ELECTRIC YACHT.—The electric yacht, "The Countess," which has been built by Messrs. Lester and Perkins, at the Royal Albert Docks, to the order of the Electric Locomotive and Power Company, was launched on Saturday afternoon last. The boat has been constructed from the designs of Mr. Lester, and is 90ft. in length, 11ft. 6in. in the

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beam, and 5ft. 6in. deep, and will draw about 3ft. of water. The motive power will be supplied by Elieson storage cells, and the screw will be driven by an Elieson motor of the pattern which has already been employed with some success for tramcar traction. The ceremony of christening was performed by the Countess of Galloway as the vessel hung suspended from one of the dock company's huge and powerful derricks. The boat was then swung bodily over the basin, and lowered into the water. The company afterwards adjourned to the workshop, where a light repast had been provided. Mr. T. Wickham proposed "The health of the Countess of Galloway," and spoke of the honour which her ladyship had done them by coming amongst them that day to perform the ceremony of christening the new boat. He felt that that was a ceremony full of promise and fraught with great advantage, not only to themselves, but to the community at large. The vessel they had seen launched that day would combine in itself two very important inventions which their company thought would some day make a very great sensation in the world. In that vessel there would be their new electric motor applying electricity in a new form, and their own accumulator or storage battery, to which they attached very great importance indeed. Therefore in thanking her ladyship for the act she had performed that afternoon, they felt that she had launched and put before the world a scheme which was fraught with great consequences in the future. They felt and hoped that the day was not far distant when not one of Her Majesty's ships or the vessels of the great navigation companies would go to sea without a launch of that kind. In returning thanks on behalf of the Countess, the Earl of Galloway said that had her ladyship not been confident of the success of the scheme they had in hand, he was certain she could not have been persuaded to assist in its development. He also took great interest in the proceedings of the Electric Locomotive and Power Company, but he did not think that vessel would have been built had it not been for the suggestion of Mr. Lester, who was one of the most active of their directors, and who by means of his firm had been instrumental in its construction. Other toasts followed.

Proposed Electric Lighting in Cork.—A special meeting of the Standing Committee of the Cork Corporation was held on Monday week to consider the representations and estimates of Mr. D. O. Bate, of the firm of Messrs. Laing, Wharton and Down, electrical engineers, London, respecting the Thomson-Houston system of electric lighting, with a view of ascertaining if the employment of such a system was practicable and less expensive than the present system of lighting the city by gas. Mr. Bate was called before the committee, and said that since the council meeting had referred him to the committee he had called upon Mr. M'Mullen, the city engineer, who had furnished him with particulars, on which he was able to base somewhat of an estimate as to the number of electric lights required to replace a certain number of gas lights. Approximately, 1,300 lamp posts carried a little over 1,300 jets, and the cost of their maintenance was £4,883. As against that, the corporation could probably profitably utilise 100 arc lights in a number of the streets of the town, leaving the small and crooked streets, which could not be lighted successfully by electricity, to be lighted in the present way. Basing his calculation at £24 per arc, the arcs would cost £2,400 per annum. At the lowest estimate each of these lamps would take the place of six gas jets. That would leave 700 gas jets in the small streets, which would cost, at the same rate, £2,629, and that, added to £2,400, made £5,030, as against £4,883 by the present system of lighting. That was an excess of £147. But in some places he could extinguish ten jets for one electric light, and, making allowance for this additional saving, he found the cost of lighting to be £4,654, £229 less than the cost at present. His esitmates were based on the figures for the year 1885. The city was illuminated by gas, at an average of nine hours per night; and he reckoned for keeping the electric lamps alight for ten hours, the same as his firm usually reckoned for English towns. If the corporation would use oil in the smaller streets, like the Waterford people, they would gain £700 a year. The Lighting Committee of Waterford had accepted the tender of his firm to light the streets of that city for the next five years, and this was now awaiting confirmation by the council. After some discussion it was finally resolved "that Mr. Bate and the engineer select within the channels the sites for 100 electric lamps, Mr. Bate then to furnish an estimate for supplying and maintaining such 100 lights for three or five years; the engineer to ascertain exactly what number of the present gas lamps might be extinguished if those 100 electric lights were erected."—*Gas World.*

Galvanometer Deflection by Alternating Currents.—The interesting and important discovery connected with alternating currents, made by Dr. Fleming in this country (and re-discovered apparently a little later by Prof. Elihu Thomson in America) renders it also interesting to note what was previously known with regard to the use of the galvanometer, with alternating currents. In Dr. Fleming's galvanometer (see *The Electrician*, May 6th) it will be remembered that the suspended needle takes the form of a thin copper disc, and the force by which it is deflected is due to the couple established between the alternating field of the coils and the Foucault currents in the disc, the latter being subject to a retardation due to the time constant of the disc, which has the effect of disturbing the equilibrium between the magnetic effect of the reversals. The fact that a *magnetised* needle is, under certain conditions, deflected in an alternating field was, however, observed by Poggendorff at least as early as the year 1838 (*Pogg. Ann.*, Vol. XIV., p. 353). The phenomenon was named by Poggendorff "Doppelsinnige Ablenkung." Thirty years later, at the meeting of the British Association at Norwich, a paper was read by the Hon. J. W. Strutt (Lord Rayleigh) "On a Permanent Deflection of the Galvanometer Needle by a Rapid Series of Equal and Opposite Induced Currents." This paper was not, however, printed in the *Transactions* of the Association, where the title alone appears. The next mention of the subject which we have been able to find occurs in 1876, when Mr. Chrystal contributed to the December number of the *Phil. Mag.* a paper entitled "Bi- and Uni-Lateral Galvanometer Deflection"; where (following Poggendorff) bi-lateral deflection refers to the deflection of a magnetised needle by alternating currents, which, under certain conditions, may be directed indifferently to either side of zero according to the accident of the first impulse, actual zero being in fact a position of unstable equilibrium. Mr. Chrystal made, however, the discovery that a different effect comes into play when the permanent field in which the needle moves is very strong compared with the alternating field, due to the current in the coils. In this case the equilibrium of the needle while at zero is much more nearly stable than in the previous case; if, however, before the current is started, the needle be moved into any position, either to the right or left of zero, then, on starting the current, it remains deflected upon that side of the scale. Mr. Chrystal enters into a mathematical explanation by which both effects are accounted for. It is, however, clear from what we now know that, owing to the Foucault current effect, the complete theory of the deflection of a magnetised needle must be very complex.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 519, Vol. XVIII.)

ERRATA.—On page 479, Vol. XVIII., the two last lines of the chapter should read as follows:—

The output $\propto \mu \times$ angular velocity $\times$ (linear dimensions) $^{\frac{7}{2}}$

or output $\propto \mu \times$ peripheral velocity $\times$ (linear dimensions) $^{\frac{5}{2}}$

Given the quality of iron we have now the necessary data from which to calculate the value of ρ,

for $$\zeta = Z_2 - Z_1 = \frac{p_1}{\rho};$$

thus $$\rho = \frac{p_1}{Z_2 - Z_1} = \frac{v}{\text{diameter of armature}},$$

v being constant for all sizes of the same type.

After the above value is thoroughly well determined by experiments made with a number of machines, the estimated maximum E.M.F. will afford a means of gauging the comparative magnetic quality of the iron, in which, by bringing this or some equally good test to bear, we may hope in time to get a more strict uniformity.

Returning to our design, we have now to fix upon the cross section of the field-magnets. Knowing the value of Z_2 (making $\sigma_2 = \sigma_1$) we have

$$AB = \frac{Z_2}{18\sigma_2}.$$

In dealing with the length of the cores, we must adopt a similar treatment to that which was employed for the dimensions of the armature, viz., a balance must be struck between the heating effect and the radiating surface.

At first sight this may seem a little difficult, because the conditions are not quite the same as in the armature, where conduction of the heat to other parts of the machine was negligible. A little reflection will, however, show that the ratio between the amounts of heat dissipated respectively from the surface of the magnet bobbin itself and from other surfaces on the frame, &c., is constant for machines of any one type. Thus, having found a coefficient giving good practical results in one case, we may be sure that it will serve for all sizes, having the same general configuration. A point of considerable practical importance arises from the above considerations, and although implicitly contained in the treatment, it will bear emphasis, viz., that the density of current in both armature and magnet winding must necessarily be diminished as the linear dimensions are increased.

For suppose the winding to consist of a single turn of solid copper, the resistance would then be inversely proportional to the linear dimensions, which we will denote by L. Thus $r \propto \frac{1}{L}$. The energy in watts absorbed in this resistance is $w \propto \frac{C^2}{L}$, and by the conditions $\frac{C^2}{L} \propto L^2$ thus $C \propto L^{\frac{3}{2}}$; but if the density were to remain constant C would vary with L^2.

Since in practice magnets have to be wound with wires of various sections in which the coefficient of insulation assumes different values, care must be taken to allow sufficient space for the smallest sizes which are likely to be used. Of course the proposition that the core surface may be used as the basis of calculation for the number of watts converted into heat in any one bobbin only holds good if the ratio between the core radius and the radius to the outside of the winding is kept constant for all sizes. This ratio, we have seen, is subject to modifications in a given size when wound for different purposes, but a constant *average* ratio may very well be maintained. It is now necessary to fix both this average ratio and also a ratio between the heat dissipated and the core surface. For the first, a good proportion will be to make the average depth of winding one-half the core radius, or, if rectangular in section, one-fourth the short diameter. For the second, a maximum of one watt per square inch of core surface will be found a fairly safe rule in general practice. We now have P the exciting power, A B the core section (from which we can also obtain the depth of winding), and a certain ratio in any given case between the length of core and the work done thereon—that is, a given number of watts per linear inch. This gives the sectional area of the wire for series winding, for then the current C flowing in each bobbin is known, and writing d for the depth of winding, w for the watts per linear inch, l for the length of a mean convolution, and A for the copper section, we have

$$\frac{d\,l\,\mu^2}{162 \times 10^4 \,.\, A^2} = \text{resistance} = \frac{w}{C^2},$$

from which A is found. The number of windings n per unit length follow immediately from this equation, and $\frac{P}{2Cn}$ then gives the length of core, the numeric being inserted because there are in general two cores to each magnet.

The length of the iron portions of the magnetic circuit are now known and have been determined in such a way as to secure for them a minimum value; the length of the air gap, δ, has, however, so far only been fixed in a purely arbitrary manner, and we must try to deal with this quantity a little more fully.

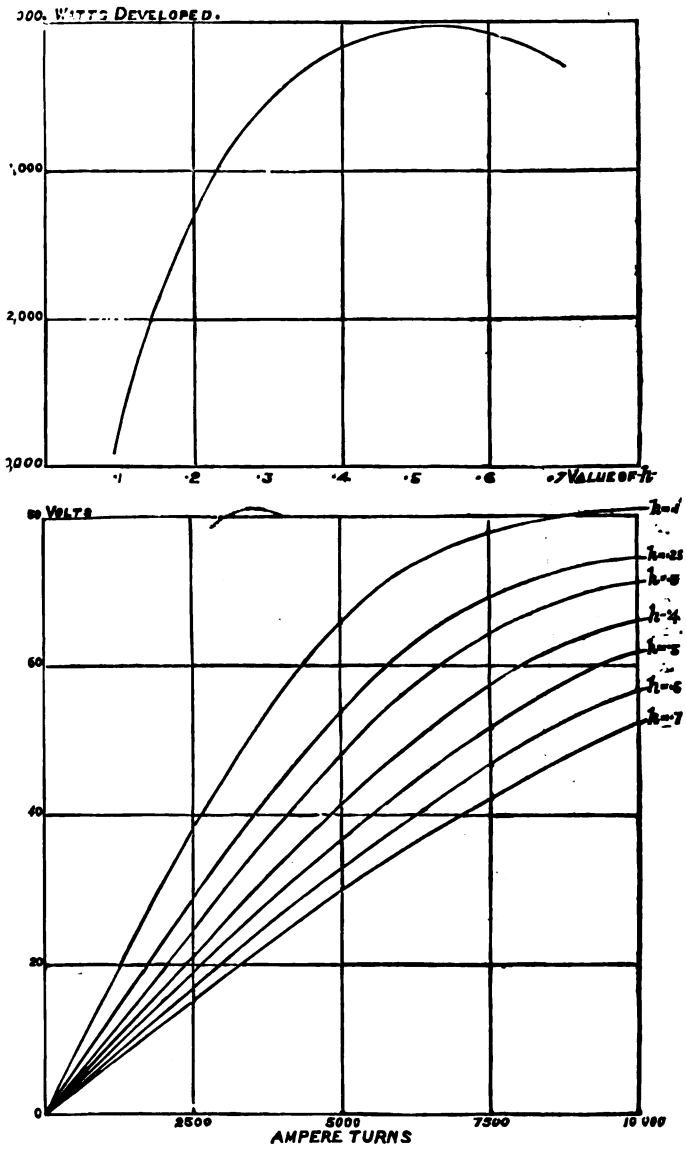

FIG. 9.

It consists of two parts, viz., the depth of winding, which we will call h, and the clearance Q necessary to mechanical safety. What we have now to do is to express the output as a function of h, in order that the effect of modifications in this latter quantity may be traced. As our object is to secure the

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beam, and 5ft. 6in. deep, and will draw about 3ft. of water. The motive power will be supplied by Elieson storage cells, and the screw will be driven by an Elieson motor of the pattern which has already been employed with some success for tramcar traction. The ceremony of christening was performed by the Countess of Galloway as the vessel hung suspended from one of the dock company's huge and powerful derricks. The boat was then swung bodily over the basin, and lowered into the water. The company afterwards adjourned to the workshop, where a light repast had been provided. Mr. T. Wickham proposed "The health of the Countess of Galloway," and spoke of the honour which her ladyship had done them by coming amongst them that day to perform the ceremony of christening the new boat. He felt that that was a ceremony full of promise and fraught with great advantage, not only to themselves, but to the community at large. The vessel they had seen launched that day would combine in itself two very important inventions which their company thought would some day make a very great sensation in the world. In that vessel there would be their new electric motor applying electricity in a new form, and their own accumulator or storage battery, to which they attached very great importance indeed. Therefore in thanking her ladyship for the act she had performed that afternoon, they felt that she had launched and put before the world a scheme which was fraught with great consequences in the future. They felt and hoped that the day was not far distant when not one of Her Majesty's ships or the vessels of the great navigation companies would go to sea without a launch of that kind. In returning thanks on behalf of the Countess, the Earl of Galloway said that had her ladyship not been confident of the success of the scheme they had in hand, he was certain she could not have been persuaded to assist in its development. He also took great interest in the proceedings of the Electric Locomotive and Power Company, but he did not think that vessel would have been built had it not been for the suggestion of Mr. Lester, who was one of the most active of their directors, and who by means of his firm had been instrumental in its construction. Other toasts followed.

Proposed Electric Lighting in Cork.—A special meeting of the Standing Committee of the Cork Corporation was held on Monday week to consider the representations and estimates of Mr. D. O. Bate, of the firm of Messrs. Laing, Wharton and Down, electrical engineers, London, respecting the Thomson-Houston system of electric lighting, with a view of ascertaining if the employment of such a system was practicable and less expensive than the present system of lighting the city by gas. Mr. Bate was called before the committee, and said that since the council meeting had referred him to the committee he had called upon Mr. M'Mullen, the city engineer, who had furnished him with particulars, on which he was able to base somewhat of an estimate as to the number of electric lights required to replace a certain number of gas lights. Approximately, 1,300 lamp posts carried a little over 1,300 jets, and the cost of their maintenance was £4,883. As against that, the corporation could probably profitably utilise 100 arc lights in a number of the streets of the town, leaving the small and crooked streets, which could not be lighted successfully by electricity, to be lighted in the present way. Basing his calculation at £24 per arc, the arcs would cost £2,400 per annum. At the lowest estimate each of these lamps would take the place of six gas jets. That would leave 700 gas jets in the small streets, which would cost, at the same rate, £2,629, and that, added to £2,400, made £5,030, as against £4,883 by the present system of lighting. That was an excess of £147. But in some places he could extinguish ten jets for one electric light, and, making allowance for this additional saving, he found the cost of lighting to be £4,654, £229 less than the cost at present. His esitmates were based on the figures for the year 1885. The city was illuminated by gas, at an average of nine hours per night; and he reckoned for keeping the electric lamps alight for ten hours, the same as his firm usually reckoned for English towns. If the corporation would use oil in the smaller streets, like the Waterford people, they would gain £700 a year. The Lighting Committee of Waterford had accepted the tender of his firm to light the streets of that city for the next five years, and this was now awaiting confirmation by the council. After some discussion it was finally resolved "that Mr. Bate and the engineer select within the channels the sites for 100 electric lamps, Mr. Bate then to furnish an estimate for supplying and maintaining such 100 lights for three or five years; the engineer to ascertain exactly what number of the present gas lamps might be extinguished if those 100 electric lights were erected."—*Gas World.*

Galvanometer Deflection by Alternating Currents.—The interesting and important discovery connected with alternating currents, made by Dr. Fleming in this country (and re-discovered apparently a little later by Prof. Elihu Thomson in America) renders it also interesting to note what was previously known with regard to the use of the galvanometer, with alternating currents. In Dr. Fleming's galvanometer (see *The Electrician*, May 6th) it will be remembered that the suspended needle takes the form of a thin copper disc, and the force by which it is deflected is due to the couple established between the alternating field of the coils and the Foucault currents in the disc, the latter being subject to a retardation due to the time constant of the disc, which has the effect of disturbing the equilibrium between the magnetic effect of the reversals. The fact that a *magnetised* needle is, under certain conditions, deflected in an alternating field was, however, observed by Poggendorff at least as early as the year 1838 (*Pogg. Ann.*, Vol. XIV., p. 353). The phenomenon was named by Poggendorff "Doppelsinnige Ablenkung." Thirty years later, at the meeting of the British Association at Norwich, a paper was read by the Hon. J. W. Strutt (Lord Rayleigh) "On a Permanent Deflection of the Galvanometer Needle by a Rapid Series of Equal and Opposite Induced Currents." This paper was not, however, printed in the *Transactions* of the Association, where the title alone appears. The next mention of the subject which we have been able to find occurs in 1876, when Mr. Chrystal contributed to the December number of the *Phil. Mag.* a paper entitled "Bi- and Uni-Lateral Galvanometer Deflection"; where (following Poggendorff) bi-lateral deflection refers to the deflection of a magnetised needle by alternating currents, which, under certain conditions, may be directed indifferently to either side of zero according to the accident of the first impulse, actual zero being in fact a position of unstable equilibrium. Mr. Chrystal made, however, the discovery that a different effect comes into play when the permanent field in which the needle moves is very strong compared with the alternating field, due to the current in the coils. In this case the equilibrium of the needle while at zero is much more nearly stable than in the previous case; if, however, before the current is started, the needle be moved into any position, either to the right or left of zero, then, on starting the current, it remains deflected upon that side of the scale. Mr. Chrystal enters into a mathematical explanation by which both effects are accounted for. It is, however, clear from what we now know that, owing to the Foucault current effect, the complete theory of the deflection of a magnetised needle must be very complex.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 519, Vol. XVIII.)

ERRATA.—On page 479, Vol. XVIII., the two last lines of the chapter should read as follows:—

The output $\propto \mu \times$ angular velocity $\times$ (linear dimensions) $^{\frac{7}{2}}$

or output $\propto \mu \times$ peripheral velocity $\times$ (linear dimensions) $^{\frac{5}{2}}$

Given the quality of iron we have now the necessary data from which to calculate the value of ρ,

for $$\zeta = Z_2 - Z_1 = \frac{p_1}{\rho};$$

thus $$\rho = \frac{p_1}{Z_2 - Z_1} = \frac{v}{\text{diameter of armature}},$$

v being constant for all sizes of the same type.

After the above value is thoroughly well determined by experiments made with a number of machines, the estimated maximum E.M.F. will afford a means of gauging the comparative magnetic quality of the iron, in which, by bringing this or some equally good test to bear, we may hope in time to get a more strict uniformity.

Returning to our design, we have now to fix upon the cross section of the field-magnets. Knowing the value of Z_2 (making $\sigma_2 = \sigma_1$) we have

$$AB = \frac{Z_2}{18\sigma_2}.$$

In dealing with the length of the cores, we must adopt a similar treatment to that which was employed for the dimensions of the armature, viz., a balance must be struck between the heating effect and the radiating surface.

At first sight this may seem a little difficult, because the conditions are not quite the same as in the armature, where conduction of the heat to other parts of the machine was negligible. A little reflection will, however, show that the ratio between the amounts of heat dissipated respectively from the surface of the magnet bobbin itself and from other surfaces on the frame, &c., is constant for machines of any one type. Thus, having found a coefficient giving good practical results in one case, we may be sure that it will serve for all sizes, having the same general configuration. A point of considerable practical importance arises from the above considerations, and although implicitly contained in the treatment, it will bear emphasis, viz., that the density of current in both armature and magnet winding must necessarily be diminished as the linear dimensions are increased.

For suppose the winding to consist of a single turn of solid copper, the resistance would then be inversely proportional to the linear dimensions, which we will denote by L. Thus $r \propto \frac{1}{L}$. The energy in watts absorbed in this resistance is $w \propto \frac{C^2}{L}$, and by the conditions $\frac{C^2}{L} \propto L^2$ thus $C \propto L^{\frac{3}{2}}$; but if the density were to remain constant C would vary with L^2.

Since in practice magnets have to be wound with wires of various sections in which the coefficient of insulation assumes different values, care must be taken to allow sufficient space for the smallest sizes which are likely to be used. Of course the proposition that the core surface may be used as the basis of calculation for the number of watts converted into heat in any one bobbin only holds good if the ratio between the core radius and the radius to the outside of the winding is kept constant for all sizes. This ratio, we have seen, is subject to modifications in a given size when wound for different purposes, but a constant *average* ratio may very well be maintained. It is now necessary to fix both this average ratio and also a ratio between the heat dissipated and the core surface. For the first, a good proportion will be to make the average depth of winding one-half the core radius, or, if rectangular in section, one-fourth the short diameter. For the second, a maximum of one watt per square inch of core surface will be found a fairly safe rule in general practice. We now have P the exciting power, A B the core section (from which we can also obtain the depth of winding), and a certain ratio in any given case between the length of core and the work done thereon—that is, a given number of watts per linear inch. This gives the sectional area of the wire for series winding, for then the current C flowing in each bobbin is known, and writing d for the depth of winding, w for the watts per linear inch, l for the length of a mean convolution, and A for the copper section, we have

$$\frac{d\,l\,\mu^2}{162 \times 10^4 \cdot A^2} = \text{resistance} = \frac{w}{C^2},$$

from which A is found. The number of windings n per unit length follow immediately from this equation, and $\frac{P}{2Cn}$ then gives the length of core, the numeric being inserted because there are in general two cores to each magnet.

The length of the iron portions of the magnetic circuit are now known and have been determined in such a way as to secure for them a minimum value; the length of the air gap, δ, has, however, so far only been fixed in a purely arbitrary manner, and we must try to deal with this quantity a little more fully.

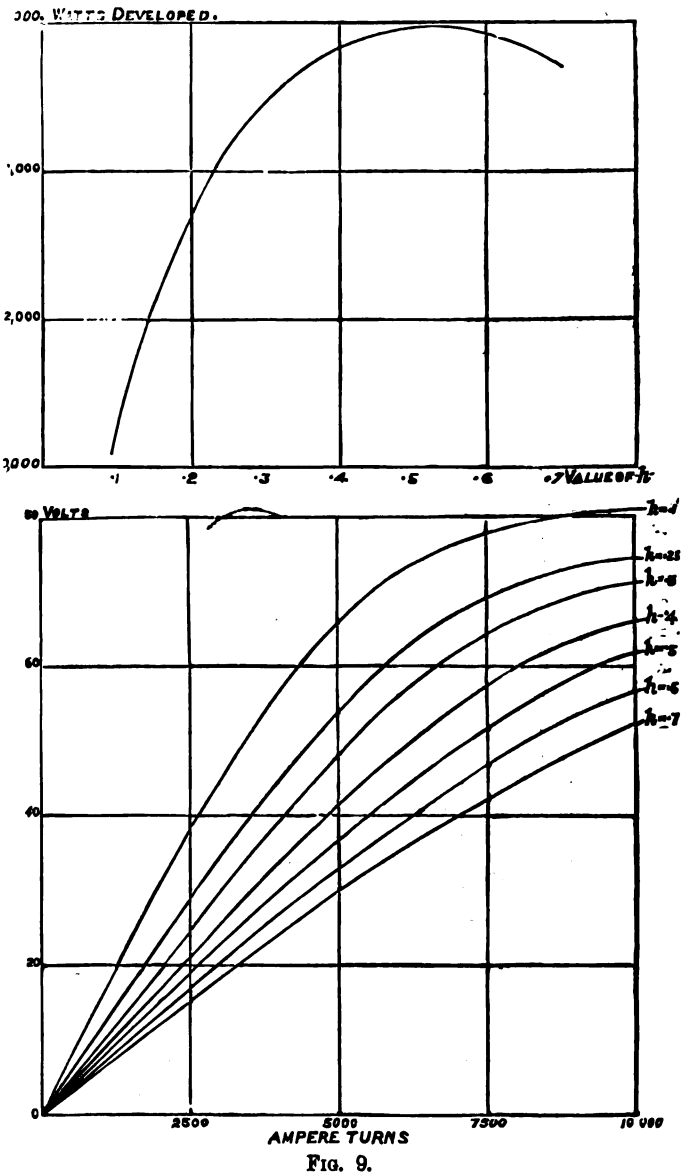

FIG. 9.

It consists of two parts, viz., the depth of winding, which we will call h, and the clearance Q necessary to mechanical safety. What we have now to do is to express the output as a function of h, in order that the effect of modifications in this latter quantity may be traced. As our object is to secure the

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highest efficiency as well as the greatest output, we will cause the two quantities to vary in the same direction by keeping the work done in the armature constant. We then have from equation (2).

$$r_a = \frac{t(a+2\beta)}{\beta(b-\beta)},$$

where $$t = \frac{N^2}{162\times10^4 . \pi\mu^2 P^2 R},$$

$$a = q+p \text{ and } b = 1-p;$$

thus $$r_a = \frac{t\left(a+\frac{2h}{R}\right)}{\frac{h}{R}\left(b-\frac{h}{R}\right)}.$$

Also $C = \sqrt{\frac{W}{r_a}}$ where W = watts in armature. We then have

$$C = \left\{\frac{\frac{Wh}{R}\left(b-\frac{h}{R}\right)}{t\left(a+\frac{2h}{R}\right)}\right\}^{\frac{1}{2}}$$

The electromotive force E can also, as we have seen, be expressed in terms of Z, the number of lines passing through the armature core. In this expression Z is a function of h, but as there is also a saturation term, k, which is affected by modifications in h, a general solution of the problem presents serious difficulties. We can, however, take a particular case, and calculate from the tangent formula already given a number of curves of E.M.F. corresponding respectively to certain values of h; a vertical line can then be struck at any suitable exciting value along the line O X, and the points of intersection with the curves will give the E.M.F. in each case. These values will then be taken to form products with the corresponding values of C, and thus another curve of the products of E C may be made in which the various values of h are taken along the line O X. Although such a curve is limited in its actual application to one particular machine, it may yet be taken as *characteristic* of all machines. A case is therefore worked out in Fig. 9 in which the constants are as follows:—

W = 600.
R = 7·625.
t = ·000336.
a = ·8.
b = ·6.
N (number of turns on armature) = 320.
n (revolutions per minute) = 900.
R_A = 1·22.
R_F = 2·85.
ρ (resistance of air leak) = 80.

	for h = ·1	33·7
	„ „ = ·23	45·5
	„ „ = ·3	51·7
Ra =	„ „ = ·4	60·7
	„ „ = ·5	69·6
	„ „ = ·6	78·6
	„ „ = ·7	87·6

SIR WILLIAM THOMSON'S NEW ELECTRIC MEASURING INSTRUMENTS.

Standard Electric Balances.

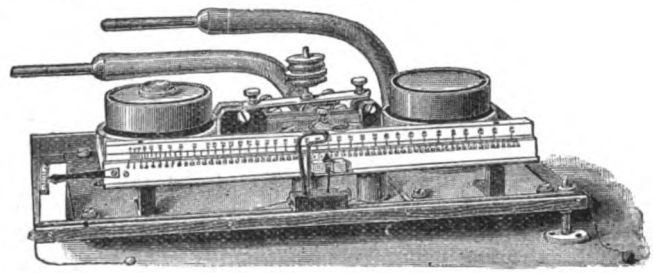
1. These instruments are founded on the mutual forces, discovered by Ampère, between movable and fixed portions of an electric circuit. The shape chosen for the mutually-influencing portions is circular, and each such part will be called for brevity an ampere ring, or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor.

2. In the balance instruments each movable ring is actuated by two fixed rings—all three approximately horizontal. In each of the balance instruments there are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm pulled, one of them up and the other down, by a pair of fixed rings in its neighbourhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In the direct reading voltmeter there is only one fixed ring acting on a single movable ring, which is attached to one end of the balance arm and counterpoised by a weight at the other end.

3. In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

4. In the balance instruments the mid-range position of each movable ring is in the horizontal plane midway or nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted by one of the fixed rings and repelled by the other.

5. In the balances to measure direct currents of from 5 amperes to 1,000 amperes the outer diameter of each pair of fixed rings is somewhat smaller than the inner diameter of the movable ring, and the proportions are so arranged that the force experienced by the movable ring is very nearly constant through half a centimetre on each side of its middle position This is the sighted position for the ordinary use of the balance; and it is marked by the zero line or middle one of five stout black lines across the scale traversed by the pointer of the balance.



Standard Electric Balance.

6. In the balance instruments to measure alternate currents of all strengths, and direct currents of from 5 milliamperes to 10 amperes the fixed rings are larger than in the instruments to measure the larger direct currents. Their outer diameters are greater and their inner diameters less than that of the movable ring which moves between them, above one and below the other. The position of the movable ring equidistant from the two fixed ones is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{2}{10}$ per cent. more than the minimum force.

7. In the balance instruments to measure alternating currents (which may be also used for direct currents) of from 5 amperes to 1,000 amperes the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering, or otherwise from its neighbour, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

8. The balancing is performed by aid of a weight which slides on an approximately horizontal graduated arm attached to the balance; and there is a trough fixed on the right hand end of the balance, into which the proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time (§ 11 below). For the fine adjustment of the zero a small metal flag is provided (as in an ordinary chemical balance) actuated by a fork, with a handle below the case outside as shown in the drawing. To set the zero, the left hand weight is placed with its pointer at the zero of the scale, and the metal flag is turned to one side on the other until it is found that, with no current going through the rings, the balance rests in its sighted position.

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9. To measure a current the left hand weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed white scale (called the inspectional scale) with aid of the finely divided scale, for more minute accuracy, according to the explanations given in § 13 below. Each number on the inspectional scale is twice the square root of the corresponding number on the scale of equal divisions.

10. The slipping of the weight into its proper position is performed by means of a self-releasing pendant hanging from a hook carried by a sliding platform, pulled in the two directions by two silk threads passing through holes to the outside of the enclosure.

11. Three pairs of weights (sliding and counterpoise) in the ratios of 1 : 4 : 16 or 1 : 4 : 25 are supplied with each instrument, adjusted so that each pair gives a round number of amperes, or half amperes or quarter amperes, or of decimal sub-divisions or multiples of these magnitudes of current, on the inspectional scale.

12. The useful range of each instrument is about from 1 to 25 of the smallest current for which its sensibility suffices. The ranges of the different types of this instrument regularly made are—

I.	Centi-ampere balance :	from 2 to 50	centi-amperes.
II.	Deci-ampere	„ „ 1 to 25	deci-amperes.
III.	Ampere	„ „ 1 to 25	amperes.
IV.	Deca-ampere	„ „ 4 to 100	„
V.	Hecto-ampere	„ „ 20 to 500	„

The following table shows for each type of instrument the value per division of the inspectional scale corresponding to each of the three pairs of weights :—

	I. Centi-amperes per division.	II. Centi-amperes per division.	III. Deci-amperes per division.	IV. Amperes per division.	V. Ampere per division.
1st Pair of Weights.	·25	1	1	·5	2·5
2nd „	·50	2	2	1·	5·0
3rd „	1·0	5	5	2·	10·0

13. The fixed inspectional scale shows approximately enough for many purposes the strength of the current; the notches in the top of the aluminium scale show the precise position of the weight corresponding to each of the numbered divisions on the white scale, and practically annul error of parallax due to the position of the eye. When the pointer is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side, to the space between two divisions, may be estimated with considerable accuracy. Thus we may readily read off 34·2 or 34·7 by estimation with little chance of being wrong by one in the decimal place. But when the utmost accuracy is required the reading on the fine scale of equal divisions must be taken, and the strength of current estimated by aid of the table of doubled square roots appended to these instructions. Thus, for example, if the reading is 292 we find 34·18, or say 34·2 as the true scale reading for strength of current ; or, again, if the balancing position of the pointer be 301 on the fine scale we find 34·65 as the true reading of the inspectioual scale.

14. The centi-ampere balance, with a thermometer to test the temperature of its ampere rings, and with platinoid resistances up to 2,000 ohms, serves to measure potentials of from 10 volts to 200 volts.

Direct-Reading Vertical-Scale Voltmeter.

15. This instrument is commonly called "engine-room voltmeter," because it can be read at such a distance as across an engine room, and requires for taking a reading no balancing manipulation as in the balance ampere meters. It is convenient not only for engine rooms, but for use in any part of an electric light installation, or in houses supplied with electric light. It shows, by inspection, whether the potential is exactly the proper amount, or, if not exactly so, by what fraction of a per cent., or by what percentage, down to 10 per cent. below or up to 10 per cent. above, it differs from the proper amount.

16. The inspectional voltmeters consist of—

a. A fixed platinoid resistance, in circuit with a fixed and a movable ampere ring.

b. A V-trough rigidly fixed to the movable ring, and carrying the weight proper to the potential to be measured and the temperature of the instrument.

c. A thermometer to show the temperature of the ampere rings.

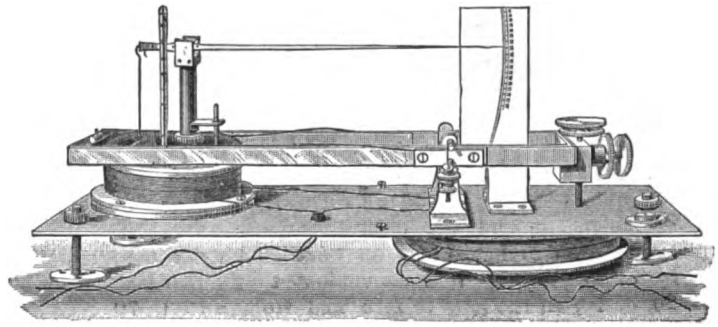
d. A lever, multiplying the motion of the movable ring, and showing the potential to be measured on a vertical graduated scale.

17. The fixed and movable ampere rings are each composed of many turns of fine insulated copper wire, with a total resistance of about 100 ohms. The amount of the added platinoid resistance depends on the potential to be measured in the ordinary use of the instrument. Thus, for example, for potentials of from 10 per cent. below to 10 per cent. above 100 volts, the platinoid resistance is 700 ohms; for potentials of from 10 per cent. below to 10 per cent. above 200 volts, the platinoid resistance is 1,500 ohms.

18. Temperature error is practically annulled in the use of the instrument by simply reading the thermometer (14 *b* and *c*), and seeing that the weight in the trough is the one corresponding to the temperature. Five weights, corresponding to temperatures centigrade of 15°, 20°, 25°, 30°, 35°, are supplied with the instrument in receptacles marked with the temperature, so that no mistake can be made in seeing that it is the right weight that is in use on the instrument at any time.

Marine Voltmeter.

19. The mass of the moving part of the balance voltmeter and engine room voltmeter is too great to be convenient for sea use, and instead a small oblate of soft iron supported on a stretched platinoid wire in the centre of a solenoid of fine copper wire, connected in series with platinoid resistances, variable according to the potential to be measured, serves for marine voltmeter. A pointer carried by the oblate shows, by inspection, direct reading of currents of from 90 to 120 milliamperes. When, as is most commonly the case, the mean potential to be measured is 100 volts, the platinoid resistance is adjusted to make up, along with the fine copper wire solenoid (of which the resistance is about 60 ohms), a total resistance of 1,000 ohms. Thus, the direct reading of potential on scale is in volts.



Engine Room Voltmeter.

20. This instrument is founded on the principle that an oblate spheroid of soft iron, movable round a diameter, tends to turn its equatorial plane parallel to the lines of force in a uniform magnetic field. In the zero position the equatorial plane of the oblate is inclined about 45° to the lines of force of the solenoid, and torsion by the upper and lower parts of the bearing platinoid wire tends to turn it into a position perpendicular to the lines of force. This tendency is balanced by a stop against the needle when no current, or any current not exceeding 90 milliamperes, passes through the solenoid. When a current exceeding 90 milliamperes passes, the torsion couple is balanced by the couple due to the electro-magnetic force.

Adjustable Magneto-Static Current Meter.

21. This instrument has an advantage over the balance instruments, important for some practical purposes, of being available as an accurate direct-reading current meter through a continuous range of from 1 to 90 or 100. Its disadvantages are that it is not available as an alternate current instrument,

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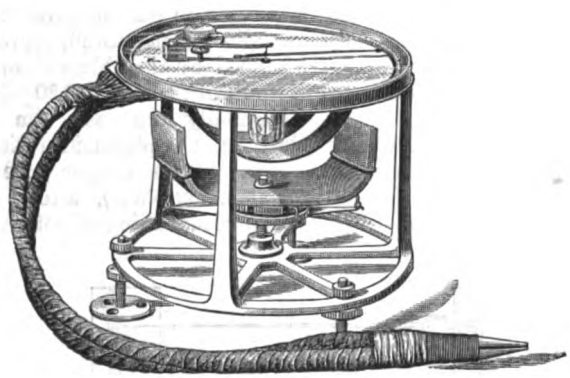
and that the magnetism of the steel directing-magnet does not remain absolutely constant. With good quality of steel, a proper preliminary *ageing* of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism may probably remain exceedingly nearly constant month after month and year after year. Still, it can never be relied upon as absolutely constant. It is therefore necessary to have some means of accurately retesting and readjusting the instrument at any time. This is always easily done with the utmost accuracy if one of the balance ampere meters is available as a standard.

22. When the instrument is used as a lamp counter, primary adjustment or readjustment, at any time, can be performed with great ease, without the aid of any other measuring instrument, by turning the screw platform which bears the adjusting magnet, so as to raise it or lower it until it is found that the deviation from zero produced by the current of any number of lights shows a corresponding number on the scale of the instrument. After each motion of the magnet the zero of course must be readjusted, which can be done either by throwing off all the lamps, or throwing the instrument out of circuit, and then turning the magnet till the needle points to zero. The lower screw must be screwed firmly up to pinch the upper screw when the adjustment is completed. If this is done firmly enough the magnet may at any time, without scruple, be turned round on its platform and brought back again whether for setting the zero, or for any other purpose, as it is only by turning the upper screw that the distance of the magnet from the needle can be altered.



Magneto-Static Current Meter.

23. The scale has 100 divisions, corresponding to equal differences of tangents of the angle between the magnetic axis of the needle and the electro-magnetic axis-vertical of the rings. The divisions may be numbered from 0 to 100; but for many purposes it is convenient to number them from 30, 20, or 10, on the left, to zero, and from zero to 70, 80, or 90 on the right; because we thus have larger divisions in the neighbourhood of the zero than when it is taken at the extreme left of the scale, and because it is sometimes convenient to measure small currents in the direction opposite to that of the currents ordinarily measured. For most purposes probably the numbering 10 left to zero and zero to 90 right will be found most convenient. With scales so numbered any number of lamps from 1 to 90 can be counted by integral numbers of scale divisions. Of course this is not possible to any great accuracy, because the lamps are not all rigorously equal, but the lamp counter serves the important practical purpose of showing at any time the exact number of lamps in use when less than 10 or 15, and nearly enough for practical purposes the exact number however many there are. In private houses it is very useful as a check against some lamp or lamps being left accidentally alight in a cellar or safe-room or other place where the fact of its being alight might escape observation for days or weeks together.

24. To count larger numbers of lamps up to 1,000 or more the instrument is made with smaller rings of more massive conductor. The same proportionate accuracy is attained as with the 100-lamp counter.

Adjustable Resistances or Mho-ohm Drum.

25. This is a combination of platinoid* conductors fulfilling the double object of an ordinary box of resistance coils in series, and a mho box by which a set of conductors can be connected any two or more of them in parallel, so that their conductances† shall be added, instead of the resistances being added, as in the ordinary box of resistance coils.

26. The conductors are coiled anti-inductively,‡ on a drum of thick sheet copper to serve the purpose, not only of bearing them and forming the main support of the instrument, but also of conducting away with great freedom the heat that is generated in each coil through which the current is flowing at any time, and so equalising the temperature of the different coils. A copper sheath is fixed outside in metallic connection with copper partition rings which separate the different coils. This sheath serves the purpose of protecting the coils against damage, and of spreading out the heat generated in each coil over a wide surface freely exposed to the external air, and so greatly diminishing the rise of temperature due to currents through the coils. It is also convenient for the application of a water jacket for laboratory or other purposes in which special care as to the temperature of the coils is needed.

27. All the resistances on the drum are connected in series by permanent solderings. The varying connections for the use of the instrument are made by circular copper cams, mounted on vertical copper shafts, connected by solderings and flexible strands with the soldered joints between the coils in series on the drum. Each shaft is mounted so as to work in two positions, an upper and a lower.

28. For making the mho connections all the shafts are placed in the upper position, and the connections are made by turning the cams so as to press on the outer or inner of two concentric copper rings between which the shafts and cams are mounted.

Explanatory Table for use of Mho-ohm Drum for Resistances.

Distinguishing Letters.	Resistances.
Block. A	1 ohm.
Block. B	2 ,,
Block. C	4 ,,
Block. D	8 ,,
Italic. *a*	16 ,,
Italic. *b*	32 ,,
Italic. *c*	64 ,,
Italic. *d*	128 ,,
Roman. A	256 ,,
Roman. B	512 ,,
Roman. C	1024 ,,
Roman. D	2048 ,,
Roman. E	4096 ,,

Explanatory Table for use of Mho-ohm Drum for Conductances.

Distinguishing Letters.	Conductances.
	$\frac{1}{2} \times \frac{1}{2048}$ of a mho.
Roman. E	1 ,, ,,
Roman. D	2 ,, ,,
Roman. C	4 ,, ,,
Roman. B	8 ,, ,,
Roman. A	
Italic. *d*	16 ,, ,,
Italic. *c*	32 ,, ,,
Italic. *b*	64 ,, ,,
Italic. *a*	128 ,, ,,
Block. D	256 ,, ,,
Block. C	512 ,, ,,
Block. B	1024 ,, ,,
Block. A	2048 ,, ,,

29. For the ohm connections the shafts are let down to their lower position, and the connections are made by turning the cams so as to short-circuit whichever of the coils are not to be included in the sum of the resistances in series. The working of this part of the plan is precisely the same as in the ordinary resistance-box, except that the short-circuitings are made with easier manipulation by cams with single contacts, instead of by removable plugs with contacts on each side of each plug. This halving of the number of the non-soldered contacts is a serious advantage.

30. In order that the single set of resistances may be available both for the connection in series (for ohms) and for the connection in parallels (for mhos) their proportions must be according to powers of 2 as in ordinary weighing by subdivi-

* When the special purpose is the measurement of the conductivity of copper, the conductors of the mho-ohm drum are made of copper instead of platinoid.

† This is Oliver Heaviside's word.

‡ That is to say, each wire is doubled on itself with the two parts everywhere close together, but well insulated from one another.

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TABLE for facilitating the Addition of Resistances in terms of Ohms on the Mho-ohm Drum.

	A	B	AB	C	AC	BC	ABC	D	AD	BD	ABD	CD	ACD	BCD	ABCD
Saxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Italic	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Roman	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840
+E	4352	4608	4864	5120	5376	5632	5888	6144	6400	6656	6912	7168	7424	7680	7936

TABLE for facilitating the Addition of Conductances in terms of $\frac{1}{2048}$ of a Mho on the Mho-ohm Drum.

	D	C	CD	B	BD	BC	BCD	A	AD	AC	ACD	AB	ABD	ABC	ABCD
Roman	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Italic	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240
Saxon	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840

Adding E to any combination of the other conductances adds $\frac{1}{2} \times \frac{1}{2048}$ of a Mho to the sum.

sion of the pound into halves, quarters, eighths, sixteenths (or ounces), and half and quarter ounces. Thus when the smallest single resistance on the drum is 1 ohm the other resistances are 2, 4, 8, 16, 32, 64, 128, 256, 512, 1,024, 2,048, and 4,096 ohms, this last being the highest single resistance on the drum as ordinarily made, but higher resistances may be added if desired.

31. The dual system, besides its availability for the two modes of connection, has this advantage, that with it a similar number of coils suffice than in any of the decimal systems of resistance coils ordinarily in use.

BELGIAN ELECTRIC LIGHTING REGULATIONS.

The following regulations for the construction of electric lighting circuits have been issued by the Belgian Postal and Telegraphic Administration :—

1. The lighting circuits shall be entirely metallic, without any earth connections whatever, and connections with water or gas pipes are strictly prohibited.

2. In the case of all portions situated upon State property, or in the neighbourhood of telegraphic or telephonic wires belonging to the State, the conducting wires, if not laid underground, shall be covered with materials which will ensure complete electric insulation, and the whole system must be made impermeable to water.

3. The cables shall be made of sufficient strength to resist any strains to which they may be exposed, and, if necessary, they shall be supported throughout their entire length by wires or metallic cables of the requisite strength, and they shall be placed at a sufficient height to allow the free passage under them of the highest vehicles, and especially of the fire escapes and ladders used for repairing the telegraph and telephone wires.

4. At their points of support on buildings, posts, buttresses, &c., the cables shall be attached in one uniform manner to porcelain insulators, and in such a way that the insulating covering may not be exposed to either mechanical or electrical deteriorations.

5. If bare wires be used for the continuation of cables carried over the places mentioned in Section 1, the bare wire shall not approach within a distance of two metres from any roof or building; it shall be furnished at the points of junction with double insulating covering for a distance of 60 centimeters at least from the supporting insulator, and the junction of the wire to the cable shall be perfectly soldered and insulated.

6. In any places where the direct and return conductors may be near together, or where a dangerous difference of potential may exist, especially in the neighbourhood of the central lighting station, the conductors shall be covered with an additional layer of insulating material; they shall be placed at a distance of not less than two metres from any roof or building, and their distance asunder shall be such as to preclude the possibility of any person touching both of them at the same time.

7. Wherever the lightning conductors cross telegraph or telephone wires, they shall pass underneath the latter at right angles, and at a minimum distance from them of 2 metres. The points of support of these cables shall be at a minimum distance of three metres on one side and the other of the telegraph and telephone wires. To prevent the wires, in the case of breakage, from coming in contact with the electric light conductors, the contractor shall place above each of the latter, along the whole length of the crossing, a metallic wire of sufficient strength

8. The electric lighting conductors and the telephone and telegraph wires shall, as far as possible, not be allowed to run parallel to one another. When this condition cannot be fulfilled the distance between them shall never be less than 12 metres.

9. In conformity with royal decree of the 15th of October, 1876, the contractor shall give to the telegraphic department the preliminary notice prescribed in Section 1 of this decree in the case of any work to be carried out in the neighbourhood of telegraph or telephone lines established or conceded by the Government.

10. The contractor must give a general undertaking to avail himself in his installations of every possible measure recognised by science or by experience as a safeguard.

The installation shall be maintained in the most perfect condition possible, and they shall be tested regularly at least once daily.

11. The contractor shall assume the entire responsibility for all damage or accident arising from his electric light installations.

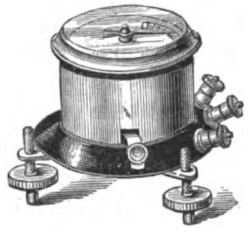
12. The present authorisation is merely permissive; it does not include the right of placing supports upon any buildings or lands belonging to the State, for which a separate authorisation must be obtained in each special case, and it may be revoked at six weeks' notice.

The State reserves to itself the right of making any changes in these regulations, of making new ones, and of demanding at any time that electric lighting conductors, situate on State property, or in the neighbourhood of telegraph or telephone lines established or conceded by the Government, be forthwith removed, without giving any indemnity to the contractor.

13. The installations carried out on State property, and in the neighbourhood of the aforesaid telegraph and telephone wires, may not be modified in the future without special permission from the Government.

NEW PORTABLE HORIZONTAL GALVANOMETER.

This galvanometer, which is illustrated below, has been designed more especially with a view for testing purposes. Its double bobbin is wound with two resistances as in an ordinary detector, and the needle which



swings inside the coils is fitted to a spindle carrying at its upper extremity an agate centre which rests lightly on a delicate needle point, a balanced aluminium pointer being fixed to the spindle just below the cap. By this arrangement a highly sensitive instrument is constituted, and one that is well adapted for testing line circuits, lightning conductor earths, &c. To prevent breakage of the needle point in transit a small lever is so fitted that upon being screwed down the spindle is lifted off its resting place. The scale is carefully engraved on a silvered dial protected by a thick plate glass cover. In using it is only necessary so to place the instrument in the magnetic meridian that the zero is towards the north, and to level it by means of the three levelling screws below the base. This galvanometer has been introduced and is manufactured by Messrs. King, Mendham and Co., of the Western Electrical Works, Bristol.

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THE ELECTRICIAN.

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THE CANADIAN PACIFIC CABLE ROUTE.

The day when wars and rumours of wars will be things of the past has not come yet, nor is that happy time likely to be known by the present generation. Many of our actions, individual and public, are dictated by the fear of what may be, and are not the result of calm reasoning. The proposed Pacific cable is one of those suggestions, and an attempt is being made to frighten the public into the support of a scheme which has few intrinsic merits to justify its claims to attention or support.

The proposed cable is either a business scheme or purely a political scheme. If the latter, the public must consider the matter as taxpayers; if the former, they must consider it as investors. The promoters seem to have an idea that it is partly a commercial and partly a political question, and that from the latter point of view the Government is to pay a subsidy as a guarantee to the investors against loss. It is singular that no ideas of this character were mooted before the building of the Canadian Pacific Railway. The letter of Mr. FINCH HATTON, given in another column, considerably clears the ground, and almost for the first time gives the real reasons why a Pacific cable is being promoted. The development of Canada is a praiseworthy object, against which we have not the faintest objection. The moral, however, of Mr. FINCH HATTON'S letter is that "Civilisation is a failure" and the "Caucasian is played out." The end of all things is to be war. Our industries are to be developed, not as peaceful industries, but as subsidiary aids in the event of war. No doubt in England we are wrong in imagining that if lines of steamers are wanted in the Pacific, lines of steamers will be provided by some of the long-headed business men who are always on the look out for means of profitably employing their capital. It might have been thought, also, that the Canadian Pacific Railway was promoted by business men for business purposes, and not from any transcendental idea of immediately directing the commerce of Australasia by a new route. We venture to deny that the transshipment and transport of goods across the American Continent will find favour in the eyes of shippers. If the Canadian Pacific Railway is to pay, it will be from the development of the country through which it runs, and for which it provides transport.

It is not so very long since a greater than Mr. FINCH HATTON argued that Canada must ultimately, and that ere long, become an integral part of the United States; and it may be asked whether this consummation of American politics is beyond the range of probabilities? If not, would not England be pickling a rod for her own back by subsidising the proposed scheme? Of course, the answer to this is emphatic, that there is no probability of such an event happening, and this answer would come from the very people who act as if the next war of England must of necessity be with a certain other nation and its allies. They claim infallibility in one direction, and no one must doubt the correctness of the views they express, otherwise it might again be objected that *viâ* Egypt was not the only route to the East, and that England has at least two other routes, and could, in a very short time, if necessary, provide a fourth, *viâ* the West of Africa, at a much less expense than by the Pacific.

We have no objection to a Pacific cable if it can be shown that it would pay as a commercial speculation, but we have a great objection to see the English taxpayers asked to contribute to a scheme which cannot pay of itself, and which is promoted solely in the hope of business from it assisting the Canadian Pacific Railway to become a paying concern. The new business opened up by the proposed cable would hardly pay for a repairing ship, and its traffic would mostly consist of traffic diverted from existing cables. In a few words the result of laying a Pacific cable would be largely and needlessly to increase the total capital invested in such means of communication to the districts under discussion—viz, the Australasian Colonies. Income would be taken from existing lines, and thus investors would lose on the one hand without gaining on the other, for it is not and cannot be contended that sufficient business would arise to give a fair return, say of five per cent., upon the total capital invested.

Before touching upon an argument which the promoters of the Pacific scheme have most unaccountably overlooked, it will be well to consider the value of one or two statements in the fourth paragraph of Mr. FINCH HATTON'S letter. He says that, "Of all lines that could possibly be laid it would be most free from any likelihood of interruption, either from natural causes or from the action of a hostile Power." Here is still seen the dominant idea that only Russia or France, and never can the United States be "a hostile power;" but the unforeseen is often that which happens, and what about likelihood of interruption if the States should be hostile? With regard to natural interruptions we can be more positive, and say emphatically that the Pacific Ocean is just as favourable or unfavourable as any other ocean. How does Mr. FINCH HATTON know that the bottom of the Pacific is the most "favourable one possible for prolonging the life of a cable," and how can he speak of great depth as being a protection? We remember the late Dr. SIEMENS advocated the deep, deep sea for safety of cables, but those who have had greater experience say that an unlevel bottom anywhere is dangerous, and the uncertainty and the cost of repairs increases greatly with the depth. From a business point of view deeply laid cables are a delusion and a snare, the bottom of the sea being as diversified as the surface of the land; and while we may think that the bottom of the Pacific is generally a level, it is

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impossible to believe that a cable can be laid the distance proposed without passing over a number of bad places. These natural difficulties, however, are such as cables have daily to encounter, and we desire only to say that the Pacific presents features no better and no worse than are constantly met with; therefore it presents no special feature to cause it to be preferable to any other route.

With regard to tariffs it may be taken for granted that if the Government sees fit to subsidise the proposed line it will deal completely with the whole question.

It has, we think, been overlooked that the arguments put forward by the promoters of the Pacific cable scheme apply to every other cable. Why should the Pacific cable be subsidised as an alternate route, and the Atlantic cables be left to fight their competitors without State aid? Surely the Atlantic cables are as necessary in the chain as the further link. If the Government is practically to be responsible for the dividend of the new scheme, surely the Government, if the cable is so essential, can borrow the money with less difficulty, at a less cost, and carry out the work themselves. The argument as to the importance of the cable system for imperial purposes leads to the inevitable conclusion that if it is so supremely important the Government should, as in the case of the inland telegraph system, take it over and work it apart from all commercial questions. The fallacy of this conclusion is at once seen, inasmuch as such action would necessitate every Government having its own cable system. It might also be asked whether the subsidisation of a Pacific cable would not rather tend to develop trade in America than with England, and, if so, why should the English taxpayer be asked to support an alternative route to his own commercial disadvantage? A number of other pertinent questions might be asked, but surely enough has been said to show that cables ought to extend more as trade develops new demands, rather than to supply routes which have the sole merit of being alternative. Were it possible to form an international tribunal, the whole cable system would be best worked as an international and unpolitical monopoly. Links here and there in the hands of different companies do not form the best means to get the best results, and were the Pacific cable laid, it would only be one link in the chain, and absolutely at the mercy of some other link.

CORRESPONDENCE.

TELEGRAPH TARIFFS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of 13th inst. you publish the final proposals submitted by Mr. John Pender, the chairman of the Eastern Extension Telegraph Company, to the recent Colonial Conference. I trust that the proposal of the Pacific Telegraph Company, which was also submitted to the Colonial Conference, and which I herewith subjoin, may prove equally interesting to your readers. I have no wish to trespass upon your valuable space by criticising Mr. Pender's proposal and the figures which it contains, for nothing that can be urged in favour of or against the existing system of cables to Australasia and the East has any bearing whatever upon the transcendant importance of establishing telegraphic communication *vid* the Pacific.

If the existing lines of the Eastern Telegraph and Eastern Extension Companies were triplicated throughout it would still leave our communications with the East in their present extremely unsatisfactory state, for there are points of weakness in the Eastern system—such as the transit through Egypt—which nothing could ever render secure. They must inevitably be destroyed in time of war, and in such places ten lines of cables, if they existed, would be just as easy to cut as one.

Everything points to the fact that in the event of war England's military route to the East must be *vid* the Canadian Pacific Railway. It is equally certain that the progress of civilisation will shortly open up the Pacific Ocean as one of the main waterways of the world in time of peace. In order to justify her enormous expenditure on the Canadian Pacific Railway, Canada must extend her communications beyond the terminus at Esquimalt by means of ocean steamers to China, Japan, and Australasia. These liners, while employed as traders and mail carriers in time of peace, could be relied on for transport of troops on the outbreak of war. But without telegraphic communication, of course, it would be impossible to open up the Pacific, either as a highway for commerce or as a military route.

By laying a line of cable as is proposed from Canada to Australia, an alternative means of communication with the East would be established possessing advantages such as no other line could possibly offer. Of all lines that could possibly be laid it would be the most free from any likelihood of interruption, either from natural causes or from the action of a hostile Power. The bottom of the Pacific Ocean is the most favourable one possible for prolonging the life of a cable, while the great depth at which the cable would be laid would be equally efficacious in protecting it, both from the injurious effects of submarine insects and currents, and from the attempts of an enemy's cruisers to cut it.

In conclusion, I would call your readers' attention to the fact that the first proposal to reduce the tariff to Australasia to 4s. per word came from the Pacific Telegraph Company. Further than this, while 4s. a word is fixed as a minimum rate by Mr. John Pender, it is the maximum rate of the Pacific Telegraph Company. Should the estimates of increased traffic be in any way realised, the company will be in a position to effect still further very considerable reductions.—Yours, &c.,

HAROLD FINCH HATTON, Secretary.

Pacific Telegraph Company (Limited),
34, Clements-lane, E.C., 16th May, 1887.

Proposition of the Pacific Telegraph Company (Limited) to the Governments of Great Britain, Canada, and the Australasian Colonies.

1. The Pacific Telegraph Company shall lay a line of cable from Vancouver Island to Australia, touching at Hawaii, Fanning Island, Samoa, Fiji, and New Zealand.

2. The Governments of Great Britain, of Canada, and of the Australasian Colonies shall guarantee to the Pacific Telegraph Company Government traffic to the amount of seventy-five thousand pounds (£75,000) per annum, in such proportions as may be mutually agreed upon by the said Governments.

3. The above guarantee shall date from the completion of telegraphic communication between Canada and Australasia by the company, and shall continue in force for twenty-five years from that date, subject to the following conditions:—

4. In the event of telegraphic communication being interrupted thirty-five days shall be allowed to the company for repairs. If at the expiration of thirty-five days telegraphic communication shall continue to be interrupted, then the guarantee shall be suspended from that date until telegraphic communication be re-established.

5. The rate per word payable by the Governments shall be the current rate charged by the company to the general public, but such rate shall never exceed four shillings per word for the transmission of messages from England to Australasia.

THEORY OF SECONDARY CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to Mr. Sprague, as far as I understand him, he thinks that electro chemists should not write thermochemical equation in the same way as other chemists, and accuses me of mixing things up because I use symbols in the same sense as nearly all modern chemists. The relation of calories and volts is perfectly understood by both Mr. Fitz-Gerald and myself, and we are in perfect accord as to facts on this point, and we only differ in notation.

Mr. Sprague says I set myself against facts; but he does not say what facts. From the extract quoted by him, it would appear that he thinks that I am wrong either in saying that

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the E.M.F. of cells cannot be measured by the heats of combination, or that the heats of combination are not measures of chemical affinity. But he does not support his assertion.

Mr. Sprague seems to think discrepancies are partly due to the neglect of the heats of solution, &c.; but I at least have been careful not to forget these. He also thinks "the value depends upon the relative values of the volt, ohm, and ampere," and asks, "Will any electrician be good enough to tell us what those units mean? What is their value? and what is the true mechanical equivalent of a 'volt-ampere-ohm-second?'" I am sorry I cannot tell him what a "volt-ampere-ohm-second" is, or what its "dimensions" are, but perhaps that is because I am a chemist.

No one has striven harder than I against the introduction of the "legal" ohm; but Mr. Sprague is wrong in saying it is related to nothing but the erroneously fixed length of a column of mercury, which no one ever made or will make. It is one of the "true units," the decimal multiples of the absolute units for which Mr. Sprague's heart yearns, and that is the reason why it has been brought forward.

Finally, Mr. Sprague goes on to say that "in the present uncertainty of what the various electrical units mean," he reckons one volt = 23,287·7 calories, which, of course, is inaccurate, in spite of the decimal, and says that we should reduce the calories of actions to the equivalent in grammes. I can only repeat that electro-chemists are only a small portion of the community, and that you cannot expect chemists to alter their notation to suit us. In the meantime, H_2O stands for 18 grams of water, and however much we might like to call it 9 grams, we are not at liberty to do so.

Mr. Williams thinks the heats of solution, or of change of physical state, cause the discrepancies between the chemical affinities and the observed heats of combination; but this is not the case. As a striking example the case of salt and snow may be taken. The intense cold is, no doubt, produced by the change in the physical state of the water; but the affinity of salt for water is not nearly enough to account for the phenomenon. If the result were controlled entirely by the chemical affinities, however small, of course the least affinity of salt for water might force the snow to melt; but in other chemical actions the physical states have great influence. For instance, reactions in solutions generally take place so that solid precipitates can be formed.

That such questions as the heats of solutions come in in cells is shown by the higher electromotive force given when strong sulphuric acid is used—that is to say, when the acid has not to be torn away from its water.

As to the last part of Mr. Williams's letter, I think we are very nearly of the same opinion. I do not regard one part of the reaction as being primary and another as a side influence, but look upon them as of equal importance. Mr. Williams and I seem to be practically of the same mind, so the point is perhaps hardly worth discussing. His apt illustration as to lifting the weight seems a very good way of putting such cases.—Yours, &c, JAS. SWINBURNE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Kindly correct an error in my letter last week. The reference to Dr. Ferguson's "Electricity" was printed as from an edition in 1886. I wrote, or meant to write, "edition 1866," and wished to show, by thus citing a little volume on my shelves, that the conception of an "electrolytic thread" was old as well as new.—Yours, &c.,

37, Burlington-road, W. E. ALDRED WILLIAMS.

THE CONSTRUCTION OF DYNAMOS.

TO THF EDITOR OF THE ELECTRICIAN.

SIR: I have been reading Mr. Fricker's articles with very great interest, and if you would oblige me by replying to the following questions I should be grateful. I have been designing a dynamo for fifteen 50-volt 60-watt lamps, on the base of the articles by Mr. C. Hering, entitled "Practical Deductions from Franklin Institute Tests." I took the diameter of armature from mechanical considerations, and then assumed a certain induction (in volts per foot) of active armature wire, which I took to be one-fourth of the whole length of wire on armature; dividing this by distance moved by armature in one second gave induction at one foot per second, and multiplying this by 100,000,000 gave lines per square foot, which divided by 144 gave lines per square inch of polar surface. The magnets I designed from experiments with small machines by a rule of thumb process. Now, I ask you, Sir, would this give reasonable results, or have I got hold of the stick by the wrong end? I must apologise for troubling you so frequently, but I am only able to get information up to date by your journal and the kindness of your contributors.—Yours, &c.,

G. T. PARDOE.

[Our correspondent has, we fear, adopted a procedure which cannot be relied upon to give him consistent results in general application. The diameter of the armature should be looked upon as the corner stone of the design, and the other quantities must be governed thereby. Mr. Fricker's papers show how this may be done in a perfectly general manner. It is not possible to predict the results of a dynamo from the information given by our correspondent, though we should be glad, if possible, to render him any further assistance in our power in the way of explanation.—ED. *E.*]

THE LIGHTING OF TURIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to a notice in your issue of the 22nd of April of a communication from a correspondent at Milan, which, being incorrect as to the facts, is likely to mislead and thus injure this company. I therefore beg you to give publicity to the following rectification:—A contract entered into between this company and the municipality of Turin for the lighting of a part of that city had been transferred by this company to Messrs. Bellani Fréres. When, however, Mr. Gaulard went to Turin to put the installation into working order, he found that the cable, which had been furnished by Messrs. Siemens and Halske, of Berlin, could not support the current for which the secondary generators were designed, the consequence being that the cable burnt. Mr. Gaulard offered to alter the secondary generators to suit a current the cable could support, but finding that Messrs. Bellani, although acting as agents of this company, had already on their premises transformers of Messrs. Zipernowski, Déri et Blatby (whom we consider infringers of our patents, and with whom we have suits pending in different countries), applied first to the municipality to verify by a scientific committee the complete and perfect working of our apparatus under the conditions for which they were constructed.

This inquiry, however, Messrs. Bellani opposed, and the whole question is therefore now being submitted to the law courts.

You will understand from the foregoing how unfair it is to imply that the alleged attempts to light a portion of the city of Turin with the Gaulard-Gibbs system were unsuccessful through any fault in that system, which is now sufficiently proved in many installations which are working perfectly.—Yours, &c., J. E. PICKERING, Sec.

National Company for the Distribution of Electricity by Secondary Generators, May 17, 1887.

SECONDARY BATTERY QUESTIONS IN BELGIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 2 of last week's issue of *The Electrician*, in connection with the above subject, the following remarks occur:—"The use of oxide of lead is certainly open to the public, since it has been shown that M. Planté had employed this method in the course of his researches long before M. Faure had dreamt of his patent." Will your Brussels correspondent kindly oblige by giving the authority from which he quotes the above remarks? For some time hints have been thrown out from reliable quarters as to the validity of the Faure patents. If, as stated, the only claim is the method of attaching and retaining the red lead, there is still some hope for a perfect secondary battery, a thing that does not exist at present. Very little interest is being taken in the improve-

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ment of grids by practical mechanics, as it is generally felt that the present monopoly is valid.—Yours, &c.,

INTERESTED.

ELECTRICAL PHENOMENA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think your correspondent "Leakage" will find that the sparks he refers to have nothing to do with the dynamo at all, but are due to high-tension electricity from the belt. I have frequently drawn sparks from my belt half way between engine and dynamo by holding an iron rule near it, and have been informed by a friend that he has frequently observed the same phenomenon with belts of wood working machinery running at high speed in dry weather.—Yours, &c.,

R. H. C. NEVILE.

Wellingore Hall, Grantham, May 15, 1887.

VOLTS AND CALORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to apologise for supposing that our eminent electricans might be right (after correcting their diatomic blunders) in assuming any reasonable relation to subsist between 23,000 calories and one volt, or, as some prefer to have it, 46,000.

I now find the whole contention to be a flagrant mistake, and for pure lovers of science and common sense, it may be instructive to inquire whether this confusion be not a characteristic effect of the high and abstract methods in which our leaders delight to hide themselves from a common gaze or appreciation.

A *calorie* is a definite amount of heat, resulting from a definite amount of combustion; whereas a *volt* has an indissoluble relation to a current, and is nothing apart from time. One *volt* is the unit of power required to perform unit work in unit time, or, in other words, it is that amount of power which is requisite to drive an ampere of current through an ohm of resistance in one second.

And if this must be compared with calories—an attempt which is probably unwise—then it must be with calories per second, and instead of 46,000, we shall find the volt or volt-ampere relation to subsist with less than one-fourth of a calorie.

If this really be the case, is it worth while to continue these interminable discussions and personal recriminations for a purely mistaken object?

Having investigated this problem from original considerations, I am pleased to find the unexpected issue to be in strict accordance with formulæ previously established by Mr. J. T. Sprague and Mr. D. FitzGerald; but it may assist and encourage some students if we repeat the unfashionable process which does not extend beyond the "Rule of Three." I sought to analyse several batteries (on paper) with different potentials and varying resistances in order to find that one *volt-ampere* invariably means a consumption of 19 grains of zinc or other equivalent per hour, and $19 \div 15{\cdot}43 = 1{\cdot}231365$ grammes per hour, which $\div$ by $60 \times 60 = {\cdot}000342$ grammes per second.

I then find that this estimate is strictly confirmed by the recent and very elaborate experiments of Lord Rayleigh and others on the direct electrolysis of copper and silver.

The volt comparison proceeds upon the assumption that if we could find out the number of calories due to an equivalent of zinc when combusted, as in a battery, then this number would represent 1 volt. How such an absurdity could have passed current is amazing to think of.

The direct combustion of zinc = Zn + O (40·5) = 42,500 calories (M. Ditte estimates 44,122). The indirect combustion of zinc in a battery consists of Zn + O = 42,500—Cu + O = 21,885 = 20,615 calories, because for every atom of zinc oxide or sulphate formed there is a corresponding atom of Cu oxide or sulphate decomposed.

These numbers are only approximative, and vary with different authorities; but the *rôle* played by the acid is not fully understood. It is indispensable to dissolve the oxide of zinc as formed; it greatly adds to the conductivity, and in all probability contributes somewhat to the E.M.F. or volt-power. Prof. Silvanus Thompson estimates the total as 23,000, or $46{,}000 \div 2$; Mr. FitzGerald estimates 23,000, and Mr. J. T. Sprague has 23,287 calories.

Now, if we accept this basis, the result easily follows:—

(1) If 32·5 grams : 23,000 calories : ·000342 grams :: ·242 calorie.

(2) If 1 calorie : 3·073 ft.-lb. : ·242 calorie :: ·744 ft.-lb.

and by way of proof or corroboration we next find that 1 volt-ampere = ·2405 gram C heat units = ·737 ft.-lb.

We thus simply deduce the result, that 1 volt of power may be maintained by the expenditure of about $\frac{1}{4}$ calorie per second.

In *The Electrician*, April 15, 1887, p. 499, Mr. FitzGerald gives some kindred equations in absolute units upon the C.-G.-S. system. What that system is I do not know, nor do I care to know; but he wisely condescends to repeat them in our ordinary or practical units. He says, heat $= \frac{CE\theta}{4{\cdot}2}$ *calories*, also E (power) $= \frac{H \times 4{\cdot}2}{C\theta} =$ *volts*, or $E = \frac{H \times 4{\cdot}2}{96{,}600} = \frac{H}{23{,}000}$ *volts*. All this refinement is doubtless A B C to him, but it is not so to many ordinary students and workers; meanwhile, his $E = \frac{H \times 4{\cdot}2}{C\theta}$ *volts* really implies "that with unit current, in unit time, $\frac{1}{4{\cdot}2}$ calorie is expended for each volt, *i.e.*, about ·24 calorie."

I do not see that a more perfect corroboration could possibly exist; nor is it at all otherwise with Mr. J. T. Sprague, who has entertained the subject in his work on "Electricity" (2nd edition), where he shows that 23,287 calories, *continued* for 97,808 seconds, would equal ·238 calorie per second; which is another way of saying that "with unit current in unit time $\frac{1}{4{\cdot}2}$ calorie is expended for each volt," or, in either case, an expenditure of about ·74 ft.-lb. per second maintains 1 volt.

There is probably a simplicity and definiteness about volts which is not well approximated by calories, and, if so, why all this furor of mistake to compare the two things? Calories depend so much both on the antecedents and consequents of a given reaction as to render its determination often a matter of great difficulty.

For the enlightenment of Mr. Swinburne it may be well to repeat with emphasis my remark that whenever moderns are impelled or necessitated to appreciate the *real* relations, they invariably do so by a "hocus pocus" arrangement, which virtually conforms to the old or equivalent view of things.

This is evaded by a flippant assumption that the two views are equally true, that mass 9 of water = 34,000, as mass 18 = 68,000; that one is as good and true as the other, but that the latter best suits the views of modern chemistry.

On the contrary, we maintain that the two things are *different*, in the sense, that one is *true*, where the other is fanciful hypothesis. Mr. Shaw and Lord Rayleigh find that *the same electrolysis* which deposits 1 of copper may also deposit 3·4 of silver.

Now *this ratio* is a fact in nature, and in accordance with all other chemical truth; but it necessitates the "hocus pocus" when the atomic weights *are supposed* to be as 63 to 108. It is precisely thus with Mr. Sabine, who found by *observation* a 10 per cent. enlargement of volume; but without the "hocus pocus" he could not have derived the same 10 per cent. from *calculation*.

These, however, are only faint ways of showing the validity of this contention as compared with the overwhelming evidence supplied by the widest assemblage of chemical facts.

Yours, &c.,

SAMUEL E. PHILLIPS, F.C.S.

NOTE ON THE REGULATION OF SERIES-WOUND TRANSFORMERS BY "INDUCTION-RINGS."

The method of regulating series-wound transformers, described in *The Electrician* of April 29th (in which lamps switched off are replaced by coils whose virtual resistance is equal to that of the lamps), will be found on examination to present some rather curious points. From the practical point

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of view the method of obtaining regulation is remarkable, from the fact that perfect regulation is obtained with an absolutely inappreciable loss of power. The following table contains some figures calculated from the data given in the article alluded to above, as follows :—

Mean alternating difference of potential at terminals of secondary coil	100 volts.
Actual resistance of each ring	1 ohm.
,, ,, ,, lamp	160 ohms.
Current through each lamp or ring in circuit	·625 a.
Total number of lamps	16.
,, ,, rings	16.
Periodic time of alternations	·01 sec.

TABLE I.

Lamps in circuit.	Rings in circuit.	Resistance of external circuit.	Work done per second (I^2R) under alternating E.M.F. of 100 volts. In lamps.	Work done per second (I^2R) under alternating E.M.F. of 100 volts. In rings.	Work done per second in the same circuit by a continuous E.M.F. of the same value.
n.	m.	Ohms.	Watts.	Watts.	Watts.
16	0	10	1,000	0	1,000
12	4	0·48	750	0·78	2,080
8	8	0·165	500	2·34	6,050
4	12	0·124	250	3·12	8,060
1	15	0·071	62·5	4·56	14,050
0	16	0·062	0	6·24	16,000

In this table the values of the work done both in lamps and rings is found from the square of the known current in each into their respective resistances, and for the sake of comparison the work which would be done by the equivalent continuous E.M.F. is added in the fourth column. It is at first a little startling to find that the continuous E.M.F. does work at the rate of about 21·5 horse-power in a circuit where the same E.M.F., if alternating with a period of 0·01 second, yields only 6·24 watts.

TABLE II.

Lamps in circuit.	Rings in circuit.	Coefficient of self induction of external circuit.	Total work done per second by Alt. E.M.F. (calculated directly from formulæ below).
n.	m.	L_0	Watts.
16	0	—	1,000
15	1	·00112	939
12	4	·00632	752
10	6	·01116	630
8	8	·01600	503
4	12	·01896	254
2	14	·01778	130
1	15	·01680	69
0	16	·01600	6

In Table II. the coefficients of self-induction for the external circuit are given in the third column. These were found on the assumption that the coefficient for a lamp is negligible in comparison with that for each ring, and the latter coefficient is taken as 0·254, this being the value required to fulfil the condition that the current through a ring shall be the same as that through a lamp.

It will be observed that the value of L_0 does not increase continuously with the number of rings in circuit; the physical meaning of this peculiarity can, however, be better explained when we come to consider the effect of the rings upon the *curve of alternation* in the remaining lamps, which we hope to do in a later note.

Before showing how L_0 is calculated, we may turn to the last column in this table, which gives the *total* rate at which energy is expended in the circuit. The figures in the column should obviously be equal to the sum of the second and third columns in Table I.; but the verification is not in every case exact to the last unit owing to the use of the slide rule. It is, however, quite sufficient to afford ample proof (if such is required) of the correctness of the method. In Table II. the work is calculated from the formula

$$W = \frac{E^2 R}{R^2 + \left(\frac{2\pi L}{T}\right)^2}$$

an expression which it will be noticed when $L = 0$ reduces to the ordinary formula for continuous E.M.F.'s. It is also, perhaps, worth noting that the denominator in this expression is the square of the virtual resistance.

If, however, the circuit contains branches then we shall have to calculate the value of L before we can use the formula. The simplest case is that in which there are n branches all having the same values of R and of L. In this case we have only to write R/n for R, and L/n for L. But when the resistances or self-induction of the branches are no longer all equal, then not only must the self-induction of the circuit be separately calculated, *but the value of R to be used in the expression for W is no longer that of the true resistance of the circuit.* In fact, to solve the problem we have to find the resistance and self-induction of an *equivalent* single circuit, that is *a circuit without branches which could replace the actual circuit without affecting either the E.M.F. or the total current.* It will be seen that the *equivalent* resistance of a circuit is quite different from its virtual resistance; both terms vary with the value of T, but the former has no meaning when referred to a simple circuit without branches.

Writing the equivalent resistance and coefficient of self-induction R_0 and L_0 respectively, the formulæ are as follows :—

$$L_0 = \frac{Q}{P^2 + p^2 Q^2}; \qquad R_0 = \frac{P}{P^2 + p^2 Q_2},$$

where

$$p = \frac{2\pi}{T},$$

$$P = \frac{R_1}{S_1^2} + \frac{R_2}{S_2^2} + \ldots\ldots$$

$$Q = \frac{L_1}{S_1^2} + \frac{L_2}{S_2^2} + \ldots\ldots$$

where R_1, R_2 . . . are the resistances of the several branches, and L_1, L_2 . . . are their coefficients of self-induction, while S_1, S_2 . . . . are their virtual resistances, the formula for which is well known. The values of L_0 in the case under consideration have been given in Table II. To find the coefficient of self-induction for the whole circuit we should merely have to add in each case the value of the coefficient for the secondary coil. It is, however, clear that this quantity will not be a constant unless the resultant magnetisation of the core lies upon the straight part of the curve. It may be interesting to give also the values of R_0, although it seems doubtful whether they have any physical meaning. The third column contains the true resistance of the circuit for comparison.

TABLE III.

n	m	R	R_0
16	0	10	10
15	1	0·92	10·6
12	4	0·48	12
10	6	0·245	11·7
8	8	0·165	10
4	12	0·124	4·06
2	14	0·083	1·67
1	15	0·071	0·78
0	16	0·0625	0·0625

W. H. S

THE MICRO-TELEPHONE PUSH-BUTTON OF DR. CORNELIUS HERZ.

(Concluded from page 17.)

When the number of stations passes a certain limit, the necessity for a central station appears, and the instrument lends itself readily to this method of working.

The system which we are about to describe is the one which for more than six months has worked very satisfactorily at the office of our contemporary. The installation includes a battery of four Leclanché elements, and an annunciator table of 16 micro-telephonic stations. Connections are made with the editorial office, the printing works, the public department, and the porter's lodge. Each station is connected with the annunciator table by means of four wires, the connections being established according to the plan shown by Fig. 15. The drawing shows all stations connected to the central office—any two stations can, in fact, be connected together permanently. The letters I, T, M, indicate the microphone, the induction coils, and the automatic switch, *b* the call push of the micro-telephone, and *d* a second call push placed above the micro-telephone push represented in Fig. 1. This second push allows the central station to be called even when permanent communication is made with one of the other stations of the system. The central station (Fig. 14) comprises a battery, P, a micro-telephone button, with bell, similar to those of the other posts, and a number of annunciators equal to that of the posts. Beneath each annunciator is a commutator for connecting any two stations. These connections are made by flexible single wire cords, terminated by plugs F (Fig. 14). With these explanations

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it is easy to understand the working of the system when the call-button, *b*, of one of the posts is pressed. The plate *d* (Fig. 17) falls, showing the number, since in pressing *b* the circuit is closed between B and C (Fig. 17) which contains the electro-magnet E. The central station connects any two stations when the two plugs F, terminating the flexible cord, are inserted in the holes corresponding to their numbers (Fig. 17). This breaks at each station the connection of the lines C and D, and establishes

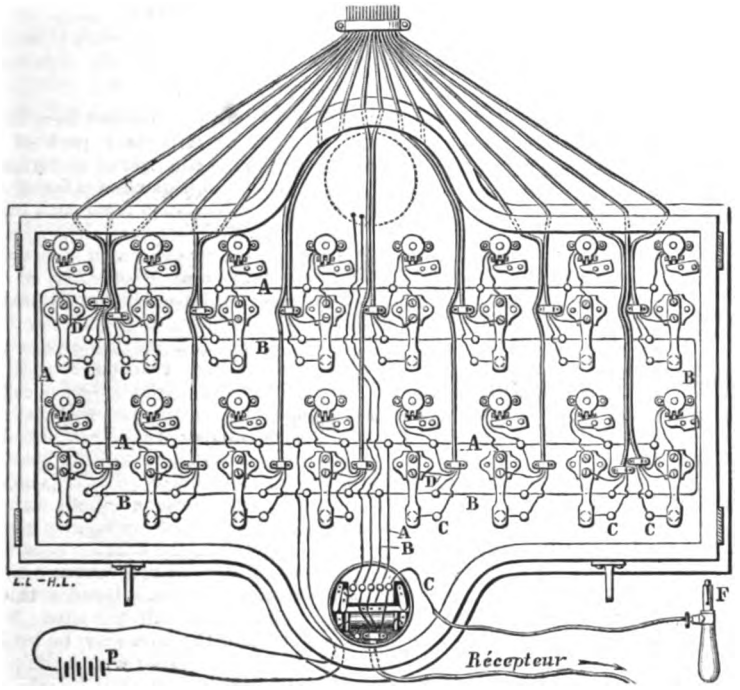

FIG. 14.

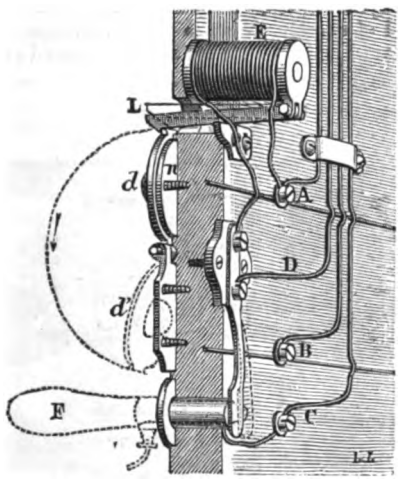

FIG. 17.

of this wire each station remains constantly connected with the central station, and by pressing the call button *d* the latter can be communicated with.

It now only remains to describe the micro-telephone, which has been designed in order to avoid as far as possible the necessity for adopting a constrained posture when holding a conversation by telephone. The instrument is shown in Fig. 16, which represents the entire apparatus

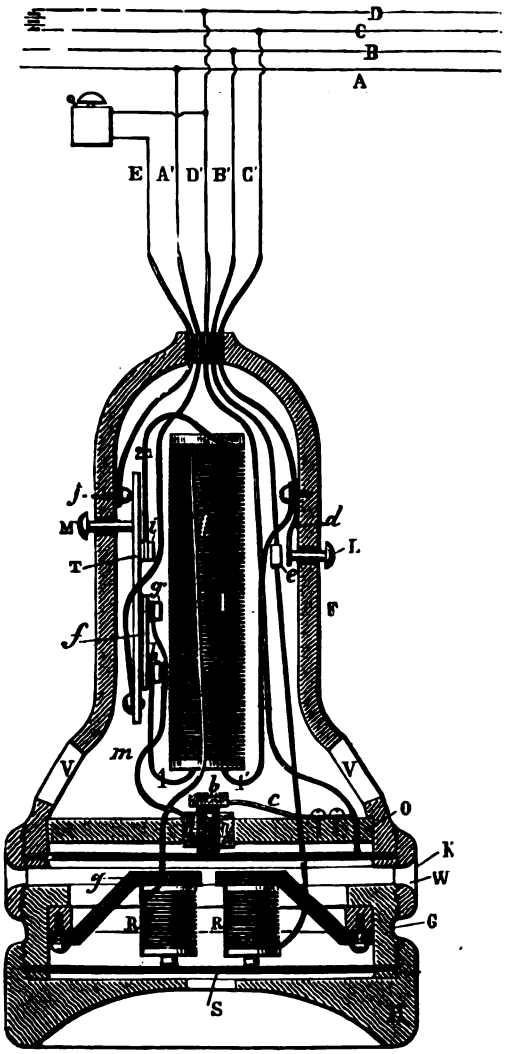

FIG. 16.

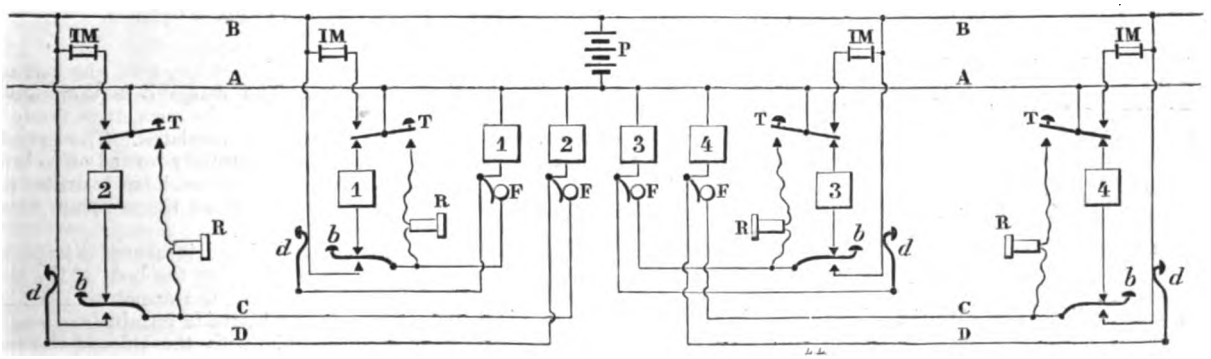

FIG. 15.

the continuity of the line C from one station to the other. The two stations are thus joined by three wires, as shown in Fig. 5, and they can call each other, and by unhooking their telephone pushes enter into conversation.

If there were only three wires, A, B, C, two stations connected through the exchange could not call the latter to ask to be connected to other stations. Hence the necessity for the fourth wire, D (Fig. 15). By means

required for one station, each set being contained in a single wooden case, having the form of an ordinary receiver, but somewhat enlarged. The handle F contains the induction coil I, the call push L, and the push M, which controls the switch by which the bells are cut out of circuit. Without entering into precise details as to the operation of this switch it will be sufficient to say that when the button is pushed in the small microphone *a b* connected with the diaphragm K is brought into circuit at

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the same time. Below this diaphragm is the receiver H, with coils R R and diaphragm S. At the back of the microphone there are a series of openings, V V, through which the sound waves reach the carbon.

The mode of using the apparatus is as follows:—The operator holds the instrument in his hand in such fashion as to close the button L. Contact is thus made between *d* and *e*, which closes the battery circuit and rings the bell at the second post. The operator at the second station, taking his instrument in hand, also presses the push L, ringing the bell in reply. The operators then each allow L to rise, and press M, which brings their microphones into circuit. For the first station the circuit is as follows: From the battery through line D, diaphragm K, microphone contact *a*, wire *n*, the contacts *g'*, *f*, *h*, the primary circuit of the coil, the spring *d*, and the line C. The circuit of the second station is precisely similar. The circuit common to the two receivers, normally open at at *i*, is now closed through the commutator T; this circuit is completed beyond the apparatus by the lines A B.

The apparatus may be held to the ear during the whole time of the conversation, and it is merely necessary to speak in an ordinary tone of voice; the sound waves spreading in all directions, pass through the openings V V, no matter in what direction the voice is uttered.

THE SLATER-LEWIS INSULATOR.

This insulator may now be regarded as a practical success, having withstood the most severe tests over a period of about four years. It will be seen from the illustration that the usual iron stud is screwed into the insulator instead of being secured by cement. The idea, however, is not exactly new, inasmuch as Mr. Cordeaux patented a similar design some seven or eight years ago, but with the addition of an india rubber washer placed on the shoulder or upper gallery on the iron bolt which supports the cup. This washer or cushion is for the purpose of protecting the porcelain threads from a dead pressure, to allow for expansion and contraction of the sundry parts, and to protect the threads from moisture and consequent rust. This rubber cushion or washer Mr. Lewis dispenses with altogether, employing nothing except the porcelain cup and the iron bolt. This is accomplished through a slight modification in the construction of the parts, and by reason of automatic machinery, which cuts the threads with unerring accuracy—a condition absolutely indispensable for the manufacture of a perfectly satisfactory insulator, because the slightest outward or upward pressure will force off the top of the cup.

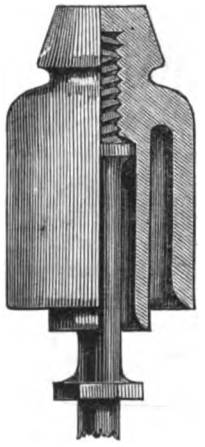

FIG. 1.

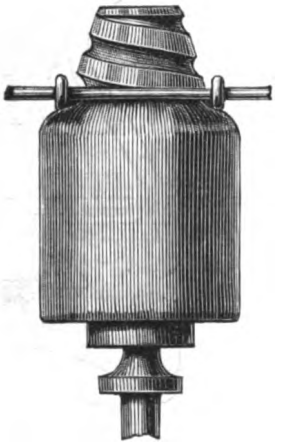

FIG. 2.

The new insulator, Fig. 1, when fixed, is brought down to a solid bearing, and the cup sits perfectly upright in its seat, whereas with the rubber washer a solid bearing is impossible; therefore there is (especially round sharp curves in the line wires) a strong tendency to pull the insulator aside and out of truth with the support, thus throwing great pressure on the porcelain threads, and causing, in many instances, complete fracture. This condition of things grows worse as the rubber deteriorates, and the decay goes on, until finally no rubber whatever remains, and the insulator is left to rock about on the stud to the damage of chafing the wire and ripping the earthenware threads.

The importance of dispensing with the rubber altogether is therefore fully apparent. About 200,000 of these insulators have already been sold to various railway, telegraph, and telephone companies at home and abroad, and repeated orders on a large scale are being constantly received. A large number of these insulators have been under trial on the postal telegraph lines for some years, and a further quantity are now being supplied under contract with the owners of the patent, the Telegraph Manufacturing Company.

The insulator is also supplied with patent self-binding screw tops, by means of which a perfectly rigid attachment is instantly made. The cups can afterwards be renewed or taken down for washing without disturbing either binder or bolt. This is effected by an arrangement of a right-hand screw on the bolt and a left-hand screw on the insulator.

This arrangement is shown in elevation in Fig. 2.

AN EIGHT-LIGHT DYNAMO.

BY GEORGE M. HOPKINS.

(*Continued from page 13.*)

The making of a good commutator is not the smallest item in the construction of a dynamo. It is a very important part of the machine, requiring good workmanship and the best of materials.

The commutator cylinder in a machine of this class is formed of a series of bronze bars, separated a short distance from each other, and carefully insulated. On the eight-light dynamo it is 1¼in. in diameter and 2in. long. The bronze sleeve A, which is fitted to the shaft and provided with a fixed flange and a set screw at one end, is screw-threaded at the opposite end to receive the screw-threaded bronze flange B. On the sleeve A, between the fixed flange and the removable flange B, is placed a vulcanite sleeve, C, and to the ends of this sleeve are fitted two collars, D, of vulcanised fiber or analogous insulating material. These collars are bevelled on their inner surfaces, and are thickest at their peripheries. To the vulcanite sleeve C is fitted a bronze cylinder, E, having conical ends, fitted to the bevelled collars, D, as shown at 5 in Fig. 6. The bronze cylinder is slitted longitudinally in a gear cutter, or in any other convenient way, so as to divide it into 24 equal divisions, the slits extending nearly through the cylinder, as shown at 1. Before the bars are separated they are marked with figure punches, in regular order from 1 to 24, so that they may be rearranged after separation. Besides this, a sheet of mica is selected which can be crowded into the slits. Now, if the slits have been made deep enough, the bars may be broken off one after another, and the fin may be removed with a file; but if the bars cannot be broken off in this way they may be removed by means of a hack saw, as shown at 2.

As many strips, F, of mica are cut from the sheet as there are bars in the cylinder, the mica strips being made a little wider than the bars and of exactly the same length, as shown at 3.

The commutator bars thus formed are placed between the collars

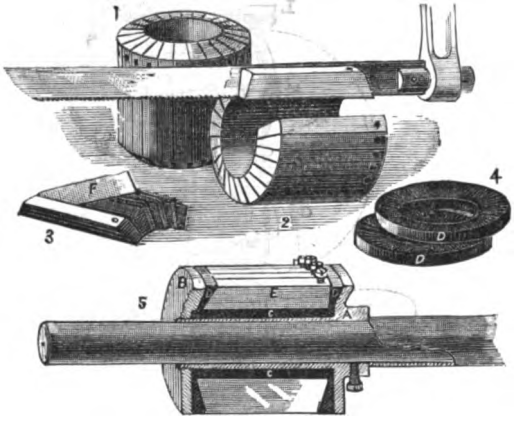

FIG. 6.—The Commutator Cylinder.

D D in alternation with the mica strips, with the bars arranged according to their numbers. The flange B is then screwed up tightly, clamping all the bars and the mica strips firmly in their places, each bar being thoroughly insulated. The cylinder thus made is placed upon an arbor and carefully turned off to bring it to a true cylindrical form. After turning, each bar is drilled near one end to receive the brass screw by which the armature wire is connected with the commutator bar.

The commutator cylinder, now finished, is secured in its place on the armature shaft with the screws adjoining the body of the armature.

Now, for convenience in handling, the armature shaft is placed in the lathe, and the inside and outside terminals of one coil are carefully straightened out parallel with the sides of the armature, and their ends are stripped of the insulating covering for a short distance and thoroughly scraped. The screws in two of the commutator bars, say 1 and 2, are loosened so as to permit of placing the looped ends of two wires under them. The outer terminal of the coil is connected with one of the screws, and the inner terminal of the same coil is connected with the screw in the next bar in order in the commutator cylinder. The outer terminal of the second coil is connected with the screw last referred to, and the

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inner end is connected with the screw of the next bar in advance, and so on around the entire commutator cylinder, the outer end of each coil being connected with inner end of the adjacent coil, and with a bar of the commutator cylinder by one of the screws, as shown in Fig. 7.

The brushes which bear upon opposite sides of the commutator cylinder are each made of six thin strips of hard rolled copper ½in. wide, and 3in. long, split from their free ends towards their clamped ends, to render them more elastic. The brushes are clamped in morticed studs passing through holes in the ends of a bar fitted to and adjustable on a boss formed on the inner side of the bronze yoke around the shaft. By this arrangement the brushes may be adjusted for taking off the current to the best

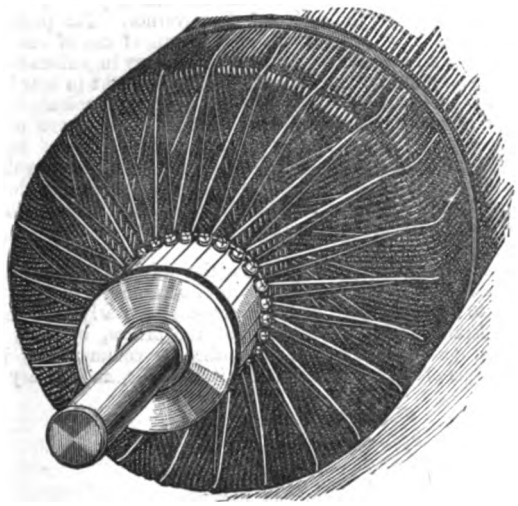

Fig. 7.—Connections of the Armature Coils and Commutator Cylinder.

advantage. The mortised studs which hold the brushes are separated electrically from the bar by insulating thimbles and washers, and upon the outer ends of the studs are screwed binding posts, in which are inserted conductors, bent into spirals to permit of the adjustment of the brushes. One of these conductors communicates with one of the binding posts on the machine base, while the other communicates with one of the rods extending to the top of the field-magnet. The remaining binding post on the base is connected with the other vertical rod, extending to the top of the magnet. These vertical rods are connected with the terminals of the winding of the field-magnet, as shown in Fig. 1.

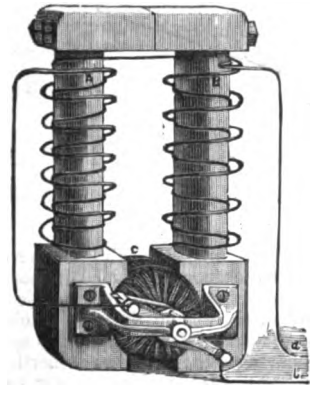

Fig 8.—Circuit of the Dynamo.

The circuit of the machine is clearly shown in Fig. 8, the current passing from the armature C, through the upper brush, thence to the top of the arm A of the magnet, down that arm, then up to the top, then down the arm B, and up, then downward to the base of the machine, terminating at *a*. The lower or remaining brush is connected with conductor *b*. From the terminals *a b* the current is taken off for use.

In Fig. 8, for the sake of clearness, only a single conductor is shown on the field-magnet, but in practice there are four, each conductor passing down and up once on each arm of the magnet—that is to say, there are eight layers of wire on each arm of the magnet, formed of four wires, each wire being laid on by beginning at the yoke, winding down to the shoulder of the polar extremity, then up again to the top, leaving the inside and outside ends projecting, as shown in Fig. 9. The winding is best done in a lathe.

In the present case all of the inner ends of the wires of the arms of the magnet are connected together, and all of the outer ends of one arm of the magnet are connected with one of the vertical rods, while the outer ends of the wires of the other arm are connected with the other vertical rod, as shown in Fig. 1.

By winding the field-magnet with No. 18 wire in the manner described, several advantages are secured, one of which is the facility with which the work of winding may be done; another is the possibility of connecting the wires in different ways so as to secure more or less resistance in the magnet. Another is that the wires may be conveniently connected up according to the various methods of winding, compound, shunt, series, &c.

As shown in the engravings, all of the wires of the field-magnet are in parallel circuit, practically forming a large conductor of small resistance, and the conductor thus arranged is connected in series with the armature—that is, the current from the armature passes directly through the field-magnet and external circuit.

Having made the dynamo and connected it up in the manner described, the brushes are to be brought into contact with the commutator cylinder at points diametrically opposite each other, and at points about opposite the centre of the space between the polar extremities of the field-magnet. The armature is revolved in the direction of the free ends of the brushes, and in the binding posts on the base are inserted short wires, which may be brought into contact with each other momentarily as the armature revolves.

If a spark is seen on the separation of the wires it shows that the magnetism inherent in the iron of the field-magnet is sufficient for the starting of the machine, and no further manipulation other than the adjustment of the brushes is necessary. The brushes should be adjusted to a point where the least sparking is produced. This will not vary much from the original position. The machine from which the engravings were made produces no noticeable sparks at the commutator.

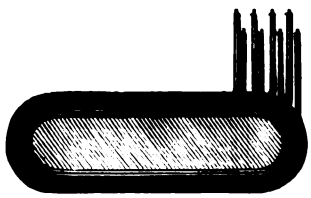

Fig. 9.—Section of One Arm of the Field-Magnet, showing Winding.

If the machine fails to start when tried in the manner above indicated a battery of four or five Bunsen cells must be connected with the binding posts, or a dynamo may be used instead of the battery. It sometimes requires a few minutes to start the current, but as soon as it begins the battery should be removed.—*Scientific American.*

MODES OF MEASURING THE CO-EFFICIENTS OF SELF AND MUTUAL INDUCTION.*

By Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., Members.

(*Continued from page 21.*)

These series of experiments have been made simply for the purpose of experimentally investigating the law of the instrument, and it is of course not at all necessary to make all these observations for the purpose of measuring the coefficient of self-induction in any particular case, nor is it necessary that the commutator should be able to be run at a number of known speeds. If the instrument is to be used to measure coefficients of self-induction the values of which do not vary between very wide limits, then it is sufficient if the instrument be constructed so as to run at one fixed speed which is not too high for the currents to become steady with the largest coefficient of self-induction that the instrument is designed to measure. If the instrument be required to measure coefficients of self-induction all having rather a large value, and also coefficients of self-induction all having rather a small value, then it would be desirable to construct the instrument so that it would run at either one low known speed or at one high known speed. The greatest sensibility in the measurement of coefficients of self-induction of which the values range within wide limits is obtained by constructing the instrument so that it can run at a number of known speeds. In practice, such a wide range instrument would be used as follows:—Before the instrument left the maker's hand the lead would be fixed and experimentally accurately determined once for all, and $60 \times l$ might be called the constant of the instrument K. An experimenter, in determining the coefficient of self-induction of any coil would—

First. Measure the resistance of the coil in the ordinary way.

Second. Rotate the instrument at some convenient speed, which must be noted, say N revolutions per minute, and by altering the resistance in one of the arms of the bridge until the galvanometer needle again comes to zero, observe the apparent increase of resistance of the coil, σ say.

Third. Rotate the instrument at some other convenient measured

* Paper read before the Society of Telegraph-Engineers and Electricians on April 28th, 1887.

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speed, say N′, and measure the apparent increase of resistance of the coil, say σ', above its original value.

Then if $\frac{\sigma}{N} = \frac{\sigma'}{N'}$, the apparent increase of resistance obtained with either speed may be used, and the required coefficient of self-induction $= K\frac{\sigma}{N}$; if, on the other hand, $\frac{\sigma}{N}$ is larger than $\frac{\sigma'}{N'}$, then the speed N′ is too high, and possibly also is N, to give accurate results. Therefore use a speed N″ lower then N, and measure the new increase of resistance σ''.

If now $\frac{\sigma}{N} = \frac{\sigma''}{N''}$ the speed N was not too high to give accurate results, although N′ was; hence the apparent increase of resistance obtained with either speed N or N″ may be used, and the required coefficient of self-induction $= K\frac{\sigma}{N}$.

If $\frac{\sigma}{N}$ be only a little *greater* than $\frac{\sigma'}{N'}$ and if N′ *much exceeds* N, then it will not be necessary to make a third experiment at the lower speed N″ unless very accurate results are desired, for the coefficient of self-induction can only be a very little greater than $K\frac{\sigma}{N}$, which may therefore be practically taken as the correct value.

By the simple addition, therefore, of such a commutating arrangement as we have described to an ordinary Wheatstone bridge, it becomes possible, whenever the resistance of a coil electro-magnet, &c., is being measured, to measure also the coefficient of self-induction in absolute measure, by a zero method which is as sensitive for the measurement of self-induction as the ordinary Wheatstone bridge method is for the measurement of resistance.

From what precedes it follows that

$$L = K\frac{\sigma - \sigma''}{N - N''};$$

so that if s_1, s_2 be the apparent resistanees of the coil at two speeds, N_1, N_2 revolutions per minute, the speeds not being too large,

$$L = K\frac{s_1 - s_2}{N_1 - N_2};$$

hence *the coefficient of self-induction can be determined from two experiments made with the revolving double commutator without knowing the true resistance of the coil at all.*

If there be doubt as to whether the speeds N_1 and N_2 are too large, a third check speed, N_3, may be used; or instead, as explained in Appendix II., a rough test of the resistance of the coil for steady currents may be made; but time need not be spent in obtaining an accurate balance, as quite a rough balance can be used as follows:—Let O on the scale be the true zero for no current passing through the galvanometer, and let the spot of light be at, say, 156 divisions when an approximation is made to balance for steady currents, the resistance of the coil appearing to be s ohms, then the zero to be used in making the *second* and *third* tests just described is $l \times 156$, where l is the lead and σ is to be reckoned as the increase above the approximate value of the resistance for steady currents.

Commercial Forms of the Instrument.

The long-range instrument previously described requires an electromotor to drive it, and a speed-indicator to register its speed, hence it would be too cumbersome for everyday work. Further, as it is very difficult to maintain the absolute constancy of the speed of a small motor driving a friction brake, like our commutating arrangement, at a high-speed for any considerable time, in consequence of very slight variations in the friction of a high-speed brake producing marked variations in the speed, it requires two experimenters to use the form of our instruments already described; one to vary the resistance until the galvanometer needle comes to zero, and the other to note the speed of the motor at the moment that the first experimenter gives a signal that the galvanometer needle is at zero.

Hence, in the autumn of last year, we were led to consider what form should be given to the commercial instrument to be used for the measurement of self-induction in this way. The main condition of the problem was that the instrument should be able to be used by one experimenter *alone*, since one experimenter alone can measure a resistance with a Wheatstone bridge, and therefore we felt that if another experimenter had to be summoned when a coefficient of self-induction had to be measured, the instrument would lose much of its practical value. Our first idea was to employ clockwork that would drive the commutating arrangement at various fixed speeds, determined by the adjustment of a certain powerful governing arrangement, and to this end commutators of very small diameter were constructed, so as to waste only a small amount of power in friction and interfere but little with the action of the governor. The problem at first sight appeared an easy one, but the experiments of one of our assistants, Mr. Bourne, whom we have to thank for the many ingenious devices that he has suggested, and for the skill that he has brought to bear in the construction of the various experimental forms that the apparatus has passed through in its development, showed that in consequence of the high speed of the commutator, and of its acting as a friction brake, good results could only be obtained with clockwork of such unwieldy dimensions as to make it impossible for the instrument to be made portable; further, it was contrary to our engineering instincts to employ an apparatus which wasted so large a portion of the power required to drive it in the governing arrangements.

When making the experiments with the original commutating apparatus, two methods suggested themselves of obtaining a balance—the one, to try and to keep the speed of the electro-motor nearly constant, and to vary the resistance of one of the arms of the bridge, by trial, until the galvanometer needle came to zero; the other, to commence by increasing one of the arms of the bridge by a definite amount, and to vary the speed of the electro-motor, by trial, until the galvanometer needle came to zero; and it soon appeared that the second method was the one that would have to be adopted in a practical instrument, since, while it is very difficult to maintain a constant speed, there is no difficulty in obtaining a gradually diminishing or increasing speed. For example, the apparatus may be provided with a fly-wheel having a large amount of inertia, and may be driven by hand more or less fast until the galvanometer needle comes to zero. The next step in order to avoid the necessity of a second experimenter was to devise a *recording speed-indicator*, and the best form that we have arrived at is based on the principle that we employed in constructing an apparatus some years ago for experiments on centrifugal force, described at a meeting of the Physical Society at the time, and in regular use in the mechanical laboratory of the Finsbury Telegraph College ever since, for experiments on centrifugal force.

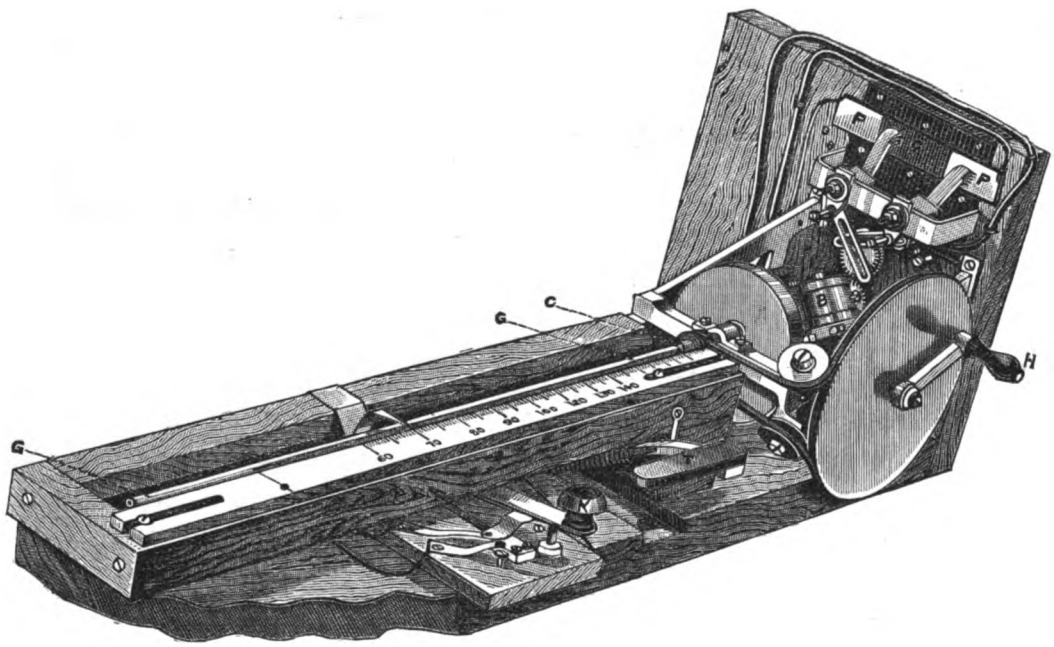

Fig. 5.—Experimental Secohmmeter.

Attached to the commutation of our self-induction apparatus is a box, B (Fig. 5), fitted with weighted elastic sides made of corrugated steel, which fly out more and more under the action of centrifugal force, as the box is rotated faster and faster. A stout glass tube, G, of comparatively small bore, open at both ends, is cemented into a collar in the axis of the box, and rotates with the box. The box is completely filled with mercury, and the tube partially, hence the volume of the box expands as its sides fly out and the length of the column of mercury in the tube diminishes, so that the length of the column at any moment is a measure of the speed of rotation of the box. In the neck of the collar, C, in which the tube is cemented, there is a steel tap attached to an axial spindle passing through a tube inside the box, and projected out of this tube at the other end of the box. If this spindle be turned relatively to the box, the

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tap is opened or closed. At the commencement of an experiment the tap is opened, and the handle H is turned with the right hand, faster and faster, until, on depressing the key K with the left hand from time to time, the galvanometer needle is seen to be approaching zero, or the spot of light the zero position on the scale. The key may now be kept depressed, and on turning the handle a little faster a speed is at length reached producing exact balance—if the handle be turned faster, the needle or spot of light deflects to one side of the zero, if more slowly to the other—at this moment the trigger T is lightly touched with the left hand and a spring is liberated. This has the effect of producing a resistance to the rotation of the tap-spindle, which previously was rotating freely with the rotating box, and the tap is thus turned off, cutting off the connection between the mercury in the glass tube and that in the box. Consequently the mercury in the tube remains, even after the instrument is stopped, of exactly the same length that it had when the trigger was touched. *The position of the end of thread of mercury in the tube is now read off on the scale attached, and the apparent increase of resistance of the coil, electro-magnet, or whatever it may be, divided by the number on the scale, gives the required coefficient of self-induction in second-ohms without any further calculation.*

The instrument is therefore *direct reading.*

This first form of recording speed-indicator was designed to be used vertically, as may be seen from the figure, but we soon found that great advantages were to be gained by placing it *horizontal.* If the glass tube be vertical the mercury in the tube exerts a pressure on the elastic sides of the box, which diminishes as the mercury falls on the speed of rotation being increased. This diminution of pressure causes the mercury not to fall so much for a given speed as it would were there no variation in the pressure due to the mercury in the tube, and so it diminishes the sensibility, hence we have been led to employ a horizontal tube. Further, since the mercury in a horizontal tube exerts no pressure on the elastic sides of the box, the amount of mercury in the tube does not in any way affect the sensibility, provided that the scale is so placed that the zero is opposite the end of the thread of mercury when the box is at rest. Hence, should any spilling of the mercury by accident occur when the instrument is moved about, the accuracy of the readings is not altered, so that by placing the tube horizontal we obtain greater sensibility and constancy in the readings.

Variations in the temperature from day to day cause alterations in the volume of the mercury, and so alter the length of the thread of mercury in the tube, but this also introduces no error in the experimental result, nor difficulty in using the instrument, since before the commencement of the experiment the scale is slightly moved until the zero on it comes opposite the position occupied by the end of the thread of mercury on the day in question when the box is at rest.

At first, rotating commutators similar to those shown in Fig. 1 were employed with the apparatus shown in Fig. 5; next the brushes were made of a variety of different forms, so as to press *radially* on the rotating commutators to prevent the wear altering the lead, and thus changing the sensibility of the instrument; but this form of commutator has at length been entirely superseded by the two oscillating arms, or brushes, A, A, worked by a cam. Each arm is composed of several pieces of hard copper, contact being made through the ends, as in many of the switches now used for electric light work. The end of each brush alternately rubs on a flat piece of phosphor bronze, P, P, when it makes contact, and on a *flat* piece of glass or agate, *g*, when it does not. This form of commutator we found superior for our purpose to the double cylindrical one, since, with the two oscillating arms, the lead can be more easily varied for adjustment; and this slight adjustment of the lead, we may here mention, forms the fine adjustment in the construction of this direct reading instrument. Further, the slow wearing of this form of brush does not alter the lead, consequently the value of the graduations of the scale remains constant.

The lead aimed at in the construction of these instruments is $\frac{1}{4}$, as that gives an equal time to each operation, but in any actual instrument it may be made a little more or less than $\frac{1}{4}$, being slightly altered, as just explained, in the final adjusting of the instrument by the maker.

It might appear, at first sight, that the two ends of an oscillating lever, or the two prongs of a vibrating tuning fork, would perform the required makes and breaks in the right order, but a reference to the cycle of operations given in the table, page 18, and a little consideration will show that the two prongs of a tuning fork cannot perform the required cycle of operations in the correct order.

Following the precedent of naming an instrument after the name of the unit employed—for example, "ammeter," "voltmeter," "ohmmeter," "wattmeter"—it seems desirable to call this instrument after the name of the commercial unit of self and mutual induction. The absolute electromagnetic unit of self and mutual induction is one centimetre, a name used by all scientific nations. But the commercial unit of self and mutual induction is $99,777 \times 10^4$ centimetres, or second-ohm, which is a little less than 10^9 centimetres, or one earth's quadrant. Now, in spite of the difference between these two numbers, which, although small, it is a pity to lose sight of, the English word "quadrant" is not used in French, therefore it would not be well to suggest this word as the international name for the unit. Yet it is most important that some name should be universally adopted, since the use of simple familiar names has much to do with making people familiar with the laws of the effect measured by the unit. The unit of electrostatic capacity, the farad, has been called after the greatest experimental worker in electricity; it would, therefore, seem appropriate that the unit of electromagnetic capacity should be called after Maxwell, the greatest mathematical worker in electricity. We do not, however, like to propose this, as we feel there might be difficulty in obtaining the general acceptance of the name of an Englishman, however great, unless it were sanctioned by an international electrical congress, or unless the man's name was intimately associated in men's minds with self and mutual induction. And Maxwell's large contribution to the subject of electromagnetic induction is surrounded by his equally large contributions to all other branches of electricity and magnetism—a giant surrounded by giants is not prominent. Coming to the last two years, we are glad that the leader and all those who have followed him in taking part in the widening of our ideas in self-induction are still with us. Hence we are driven to suggesting a temporary name for the unit, and as the first three letters in "second" are common to the name in English, French, German, Italian, &c., and ohm is also common, we venture to suggest "*secohm*" as a provisional name, and our instrument we will therefore call a "*secohmmeter.*"

(To be continued.)

FIFTY YEARS' PROGRESS IN TELEGRAPHY.*

By W. H. Preece, F.R.S., Vice-President of the Society.

This is the Jubilee year of the electric telegraph in England. On July the 25th, 1837, the first practical trial of telegraphy was made between Euston and Camden, on the London and North-Western Railway, by Cooke and Wheatstone. Nine tedious years were spent in endeavouring to create enthusiasm among financial circles for this young and novel means of communication. The first company formed to develop the business of transmitting and delivering written telegrams was incorporated in 1846, and was called the Electric Telegraph Company. Wires were speedily extended to every great centre of trade along the great railways that were then being developed, and about 1851 the business was fairly established. Telegraphy and railways have grown up side by side. In 1851 submarine telegraphy was proved to be practical. Cables were laid in 1852 and 1853 to France, Belgium, Holland, and Ireland, and from that year domestic and international telegraphy grew and prospered. The Electric Telegraph Company suffered the fate of all prosperous initiators of that which is novel, useful, and successful. The validity of their patents was contested, the strength of their business was assailed all along the line by enterprising competitors. Their monopoly was broken, but the public gained by this active rivalry greater development of communication and considerable reduction of rates. We see the same process going on at the present day with respect to telephones, but with less success.

The rates for messages, which were as high as 12s. 6d. for twenty words, were based on a sliding scale. The rates for a message of twenty words were fixed at 1d. per mile for distances under 50 miles, then $\frac{1}{2}$d. per mile up to 100 miles, and $\frac{1}{4}$d. per mile for a distance of more than 100 miles; addresses forming part of the twenty words. A message to Glasgow cost $8\frac{3}{5}$d. per word, to Manchester $5\frac{1}{5}$d.

Various reductions took place from time to time. In 1864, that is in less than twenty years, three great companies competed in every principal town for this profitable business of telegraphy. The United Kingdom Telegraph Company was formed in 1861 to introduce the universal shilling rate; but the severity of the competition of their opponents was too great for this spirited company, and they had, in 1865, to submit to the following general tariff:—Within London and other towns, 6d.; within 100 miles, 1s.; within 200 miles, 1s. 6d.; over 200 miles, 2s.—addresses being sent free.

The public now began to suffer. Only the larger towns, where profitable business could be tapped, were served. The smaller towns were neglected, and great villages had to suffer the aggravation of seeing posts and wires pass through their main thoroughfares without being able to avail themselves of this speedy mode of communication.

Telegraphy became a necessity of the age for the due and proper transaction of business. It became so closely allied with other modes of communication that public opinion, in 1868-9, forced the Government to purchase and absorb all the telegraph companies, and to transfer their business to the care of the Post Office, which had shown itself so capable in dealing with letters and newspapers, and in establishing the penny post.

The telegraphs of this country again became a great monopoly; but there is a vast difference between a monopoly in the hands of a private speculative corporation, subject to no control but that of its own closed ring, and whose sole object is to earn dividends or to make money, and that in the hands of the Government, whose sole object is to serve their masters, the public, faithfully and well, and whose actions are incessantly supervised by the jealous and watchful eyes of those they serve, who have an equally watchful and much less tolerant press in which to air their wrath and grievances, and an active House of Parliament ever ready to counteract and reform real abuses when fairly and properly laid before it.

It is impossible to conceive supervision more complete than that to which the Post Office is subject. The receiver of every letter, the transmitter of every message, the editor of every paper, the reader of every news despatch, every householder or business man, can see for himself how his own business is conducted; he can growl and grumble to his heart's content at any error or delay that may occur, with a certain knowledge that his complaint has been heard, and, if just, remedied, although he may not always be satisfied with the attention he receives. The telegraphic business of this country has reached its present dimensions because the work has been done well, and it has been done well because the mode of doing the business has been so well and so thoroughly supervised by the public.

The transfer of the telegraphs to the State took place on February 5th, 1870. The tariff established by Parliament was a uniform tariff of 1s. for twenty words, addresses being sent free, and this tariff remained in force until October 1st, 1885, when the present simple word tariff of $\frac{1}{2}$d. per word, irrespective of distance, and including addresses, with a minimum of 6d., was introduced.

The average cost for the transmission of a telegram immediately before the transfer was 2s. $1\frac{1}{2}$d. After the transfer it was reduced to 1s. 1d. It is now 8d.

* Paper read before the Society of Arts, on Wednesday, May 18.

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The number of offices open to the public prior to the transfer was 2,932, but owing to the existence of three large companies in the same town, the number of towns in telegraphic communication was probably not more than 2 500. There are now 6,514 offices open to the public. [See Appendix I.]

But the amount of business done is a better criterion of the benefits that the public have derived from the transfer of the telegraphs to the Post Office. At the close of the year 1870 the gross receipts of the Telegraph Department were £612,301; at the close of 1886 they were £1,787,264, and at the close of this year they will probably reach £1,950,000. The number of messages transmitted in 1869 were 6,000,000; in 1870 they were 9,850,177; in 1880 they were 26,547,137; in 1886 they were 39,235,813; and at the end of this year (1887) they will probably exceed 52,000,000. [*Vide* Appendix II.] Diagram I. exhibits graphically the rate of growth of messages and wires, and it illustrates pointedly the result of the ½d. per word tariff, whose success has exceeded all estimate and anticipation.

The development of telegraphy is better shown in our great central station than anywhere else. The following Table is interesting:—

Date.	One day's messages.	Instruments.	Staff.		
			Male.	Female.	Total.
Before transfer..	8,500	...	...	...	...
1870.....	12,000	350	280	485	765
1880.....	43,000	486	826	598	1,424
1886.....	98,570	945	1,490	802	2,292

The number of messages dealt with each day ranges from 70,000 to 100,000, nearly half of which are transmitted messages which have to be both received and forwarded, and therefore become, practically, two messages, although they count as only one in the total.

The local traffic in London—that is, messages emanating from one part of London for delivery in some other part, and passing through the central station—is very large. It ranges from 12,000 to 18,000 messages per day. In 1868 there were 60 offices open in the metropolis, dealing with 300 messages per day; there are now 480 offices, dealing with an average of 15,000 messages a day.

The total number of local metropolitan messages for four weeks was:—February, 1870, 138,534; January, 1880, 726,199; January, 1887, 1,277,838—a tenfold growth nearly.

Press Arrangements.

One of the great objections raised against the absorption of the telegraphs by the State was the difficulty which the Government would have in transmitting news. In no country is there now such a complete system of telegraphy for news purposes as there is in the United Kingdom. Two complete news circuits serve always (day and night) the following important centres from London:—

1. Newcastle, Edinburgh, Glasgow, Dundee, Aberdeen.
2. Nottingham, Sheffield, Leeds, Bradford.
3. Birmingham, Manchester, Liverpool.
4. Bristol, Gloucester, Newport, Cardiff, Exeter, Plymouth.
5. Brighton, Portsmouth.
6. Dublin, Cork, Belfast.
7. Northampton, Leicester, Derby.

There are several other groups in the provinces served from these centres, and every evening after six p.m. a third, and frequently, especially in the Parliamentary Session, a fourth circuit is made up to all these stations from London. Each office on each of these groups receives simultaneously the news sent from London. Thirty newspapers obtain the use of special wires, with clerks' services, from 6 p.m. to 6 a.m., many, like the *Scotsman*, the *Newcastle Chronicle*, and the *Manchester Guardian*, having two circuits; and whenever any great political event arises, such as the delivery of a great speech, all the important towns throughout the kingdom receive simultaneously a *verbatim* report of the speech. There is not a town in the country where a daily paper is printed which is not placed, after 6 p.m., in direct communication with London, and which does not deposit on every subscriber's breakfast table a nearly *verbatim* report of the previous night's debate in Parliament.

The press rates are very low. The average price paid is a little in excess of 2d. per 100 words. This entails a loss to the department roughly estimated at £200,000 a year, which is the amount the public is taxed for the support of the press. It is doubtful whether Parliament knew when it passed this low rate that it virtually meant a subsidy to the press. The loss might be very materially diminished if there were less competition and more union among newspapers and news agencies. As it is, the same matter has frequently to be sent twice over the same route, and the amount of unnecessary news sent, and therefore unnecessary expense incurred, is enormous, much of it finding its way into the waste paper basket. The supply of news before the transfer was very meagre. Reuter's telegrams, Parliamentary reports, general news, markets, races, were supplied for £200 a year. The companies did this jointly, and news was collected as well as distributed; but the Post Office is simply a carrier. It is not allowed to collect, and it has thus saved much of the obloquy that attached to the irresponsible monopoly of the telegraph companies. The average number of words supplied to each newspaper was said to be 4,000 a day. It is now roughly estimated at about an average of 12,000 in the recess, and 15,000 or 20,000 in the session.

The following will give some idea of the total number of words sent on one evening, on important political occasions, from the central station:—

April 8th, 1886.—Mr. Gladstone's Home Rule Bill, 1,050,500 words.
April 16th, 1886.—Land Purchase Bill, 841,500 words.
June 7th, 1886.—Irish Government Bill (Division), 863,700.

Appendix III. shows how rapid and great has been the increase in this branch of our business.

Apparatus.

It is perhaps in the character and form of the apparatus used to transmit messages that the greatest progress has been made. It is difficult to say whether increased business has led to better apparatus, or whether beautiful apparatus has led to large business. One thing is certain that the better the work is done the more is business encouraged, and work cannot possibly be well done if the apparatus used for discharging that business is inefficient or backward. When the Post Office assumed the control of the telegraphs, it amalgamated in to one department an incongruous combination of various systems, worked by differently trained staffs, due to the various companies having been formed at different periods to inaugurate different patents. The Electric Telegraph Company established the needle system of Cooke and Wheatstone, the printing system of Bain, which merged into that of Morse, and the various improvements patented by Varley; the Magnetic Company fathered the magnetic system of Henley and the bell system of Bright; the British Company introduced the system of Highton; the United Kingdom Company promoted the beautiful type-writer of Prof. Hughes; and the Universal Private Company was established to introduce the simple A B C system of Wheatstone.

We had telegraphs that appealed to the eye like the needle, those that appealed to the ear like the bell, some recorded signals in ink like the Morse, others printed their characters in bold type like the Hughes. Some were slow but simple like the A B C, others were fast but complicated like the automatic. Time and patience were needed to consolidate into homogeneity this heterogeneous collection of telegraphs and telegraphists. Some years elapsed before the doctrine of the survival of the fittest was asserted.

Now, in 1887, the predominant feature of our telegraphs is the simple sounder and the fast speed automatic recorder. Reading by sound is confined almost exclusively to the United Kingdom and to the United States. In Europe there is scarcely a sounder outside our islands. This is very remarkable for the sounder is simpler, more expeditious, and more accurate, than any other key system. Those who have been educated to regard a record as an element of accuracy can only be convinced by actual experience that it is an element of error, and this experience they will not seek. The argument they use against its adoption, viz., its liability to error is the very reverse of the fact.

Comparative Return, showing the Number and Description of Telegraph Instruments in the United Kingdom.

Year.	Automatic.	Sounders	Printers.	Needles.	Bells.	A B C's.	Miscellaneous.	Total.
1877...	164	1,294	1,692	3,680	210	4,572	129	11,741
1878...	167	1,380	1,560	3,495	277	4,641	859	12,376
1882...	224	2,000	1,330	3,791	313	4,398	2,035	14,091
1886...	384	3,181	1,368	4,003	388	3,883	5,179	18,386

During the past ten years a complete revolution has been effected in the quality and manufacture of our instruments. Exact measurement and scientific principles have supplanted rough and ready methods. Complete specification and rigid inspection have replaced cheap and nasty competition. The workmanship of a good telegraph instrument is to be rivalled only by that of a chronometer. Technical training has converted the workshop into a scientific laboratory.

The rapid increase of business that resulted from the uniform shilling tariff soon led to the erection of more wires, and the multiplication of wires soon attracted attention to methods of duplexing and quadruplexing the circuits. The duplex system means a mode of sending two messages in opposite directions at the same time. This was shown to be possible by Gintl, in Vienna, in 1853, but the necessity for such a system did not arrive until 1872, and as at the moment a want is felt something is sure to turn up to supply this want, so when duplexing was needed Mr. Stearns arrived from America with a well worked out practical system that was at once adopted, improved, and perfected. Still further congestion arising, quadruplex working, or the art of sending four messages on one wire at the same time, became desirable, and a practical quadruplex system, due to Mr. Edison, was imported in 1877 from the same inventive and practical region, the United States. Later on, in 1885, a still further development was matured in America, viz., the multiplex system of Delany, by which six messages can be simultaneously sent, which we have adopted, and the main features of which I now show you in action. The chief reason why these systems have been matured in America is that the want has been experienced there before here. Neither system was invented in America—each was invented in Europe. There are other wants that have been experienced here before there, and those who have visited the States have found that English inventions are equally appreciated and adopted there. It is in automatic telegraphy that we have made the greatest advances. The following table illustrates the progress made.

	Words per minute.	Speed to Ireland.
1870	80	50·3
1875	100	70
1880	200	150
1885	350	250
1887	450	450

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This increase has been due not only to improvement in the design of the apparatus, but to the steady examination of every defect and its removal, in the instrument and on the line. It would require a paper of itself to narrate the ten years' conflict with electro-magnetic inertia, static induction, climatic influences, and battery defects. The table tells the result of this conflict, and the battle is not yet over; and diagram I. shows how scientific methods and improved apparatus have checked the rate of growth of wires, and have made cheap telegraphy possible. There still exists in our system a potentiality of expansion. We are now attacking the wires. Copper is replacing iron on our poles, with very advantageous results. Its better conductivity, and its entire freedom from electro-magnetic inertia, give it an immense superiority over iron. Its greater price per ton is compensated by its lesser weight per unit resistance.

We are also examining and testing various modes of laying wires underground, with a view to attaining greater speed of working, which hitherto has checked the establishment of underground work.

One consequence of the introduction of these advanced systems of working has been the necessity to educate the operating staff in the scientific and technical details of the business. The absence of technical knowledge in all branches has hitherto been a great difficulty to surmount. The technical examinations inaugurated by this society, and continued by the City and Guilds Institute, have been most beneficial, but the most successful incentive has been the selection and promotion of those who have given their attention to their own scientific education. This evident necessity for technical knowledge is reacting on the higher Post Office officials, and one finds all over the country a healthful spirit of inquiry arising—a striving after something better than the mere perfunctory discharge of official duties. There is something so captivating in the development of the practical applications of electricity, that those who make a study of it, especially experimentally, find in it more real enjoyment than any puzzling over the vagaries of the modern poet, or poring over the meaning of ancient cynics. A successful experiment is a distinct revelation—an admission into courts where, according to Bacon, are found "secrets not dangerous to know, sides and parties not factious to hold, precepts not penal to disobey."

(To be continued.)

PHYSICAL SOCIETY.—May 14.

Prof. W. E. AYRTON, Vice-President, in the chair.

Mr. T. Mather was elected a member of the society.

The following papers were read:—*On a Modification of a Method of Maxwell's for Measuring the Coefficients of Self-Induction*, by E. C. RIMINGTON. The method referred to is given in Maxwell's "Electricity and Magnetism," § 778, Vol. 2, and is called "Comparison of the electrostatic capacity of a condenser with the electro-magnetic capacity of a coil." The apparatus used consists of a Wheatstone bridge having the coil in one, and the condenser as a shunt to the opposite, arm. In order that no deflection may be produced, either for steady or unsteady currents, a troublesome double adjustment of the resistances is necessary, and to obviate this the modification was devised. It consists in placing the condenser as a shunt to only part of the arm, and this part can be varied by sliding contacts without altering the whole resistance of the arm. An ordinary resistance balance for steady currents is first obtained, and the sliders are then adjusted until no deflection is produced on breaking the battery circuit. Under these circumstances, it is shown that $L = Kr^2 \frac{D}{B}$, where K is the capacity of the condenser, r the resistance between the sliders, and D and B the resistances of the arms in which the coil and condenser are placed. The conditions of maximum sensibility are investigated, and also those under which a telephone may replace the galvanometer; in the latter it is shown that the only possible solution is when $r = B$, *i.e.*, Maxwell's arrangement. The author believes his modification would be made much more sensitive by adopting the "cumulative" method used by Profs. Ayrton and Perry in their secohmmeter, and in his case neither the speed nor the "lead" need be known. Mr. W. N. SHAW asked whether any serious difficulties were experienced with telephones, owing to electrostatic capacities of wires, &c., and Mr. W. E. SUMPNER pointed out that the particular arrangement given in Maxwell is not always the most positive, as was shown in his remarks at the last meeting of the Society of Telegraph-Engineers. Mr. BOSANQUET thought the method a valuable one, and hoped many experiments would be made on coils whose coefficients were calculable, in order to find out the differences between calculated and observed results. Prof. AYRTON referred to the recent paper by Prof. J. J. Thompson in the *Philosophical Transactions*, and pointed out that the formula there given for the capacity of a condenser in electromagnetic measure is identical with that given in Maxwell § 776, when the printer's error of interchanging a and α in the denominator for R_2 is corrected.

On a Magnetic Potentiometer, by A. P. CHATTOCK, read by Prof. REINOLD. The so-called magnetic resistance between two points on a magnetic circuit may be expressed as the ratio of the difference of potential to the total induction passing from one to the other (provided there be no magnetomotive force between them). From the fact that the volume integral of induction through a wire helix of constant cross section is proportional to the average difference of potential between its ends, it follows that any alteration in that difference of potential will give rise to an E.M.F. in the helix proportional to that alteration. Hence, if the wire be connected to a ballistic galvanometer, the combination may be called a magnetic potentiometer. A helix is formed by winding wire uniformly on a piece of solid indiarubber or canvas gas tubing of constant cross section, using an even number of layers to avoid external inductive effects, and leaving a small space between the turns, so as to allow the tube to bend without elongating. Experiments made to measure the difference of potential between the ends of a magnet gave satisfactory results. One end of the helix was held stationary at one end of the magnet, whilst the other was moved quickly to the other end of the magnet, and the resulting throw of the galvanometer observed. This was next done at two operations, and the sum of the two throws was very nearly equal to the first. The results can be reduced to absolute measure by passing the helix through a coil of n turns, bringing its ends together, and starting or stopping a current C in the coil, the resulting throw of the galvanometer being noticed. The magnetomotive force used in this experiment is $4\pi nC$. An interesting discussion followed, in which Prof. PERRY, Mr. SHAW, Prof. AYRTON, and Mr. BOSANQUET took part, the latter mentioning a measurement of magnetic potential made by himself some years ago. In consequence of the absence of Prof. S. P. Thompson, his paper on secondary generators was postponed till next meeting.

LEGAL.

Anglo-American Brush Company v. R. E. Crompton and Co.

This was an appeal from the order of Mr. Justice Kay directing a commission to the United States to take the evidence of Mr. C. F. Brush at the instance of the plaintiffs. We understand the appeal was in consequence of what the defendants considered to be insufficient affidavits on the part of the plaintiffs to justify a commission, but further affidavits having been filed stating further communications since the date of the order, the Court of Appeal declined to depart from the established practice in these cases and confirmed the order of Mr. Justice Kay.

COMPANIES' MEETINGS & REPORTS.

West India and Panama Telegraph Company (Limited).

The twentieth ordinary general meeting of the members of the West India and Panama Telegraph Company (incorporated 9th January, 1877) was held at Winchester House, 50, Old Broad-street, E C., on Wednesday, the 18th inst., under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the previous meeting, which the Chairman signed as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, this time last year we had to announce to you that there was a falling off in the traffic receipts of a little over £2,000 for the last half of the year 1885. This half year our traffic receipts are practically the same as they were at that time. I think telegraph receipts are (political disturbances set aside, and there are no political disturbances in the West Indies) a very good barometer of the state of trade in any region that the telegraph serves, and therefore we may deduce from the circumstance that our traffic receipts continue to be the same as they were this time last year, that the same depression in the sugar trade exists now as it did then; indeed, the prices ruling in the sugar market confirm this view. We find that sugar, which generally speaking used to be worth £1, is worth now only 11s. to 12s. per cwt., and I need not say that the sugar industry causes the chief source of our revenue. At the same time we have been very unfortunate in the matter of repairs, a circumstance which we cannot control. The movements of the sea, the earth, and the winds are beyond human control, and they affect our cables sometimes very prejudicially. This half year we have had twelve cables interrupted, while in the corresponding period of last year we had only ten interrupted. The length of cable used has been in excess of that required during the corresponding period of last year. We had one very long piece repaired in the Jamaica-Colon section after prolonged and costly operations, owing to the great depth of water in which it lay. As stated in the report, the cable was recovered finally at a depth of 1,613 fathoms. The ship was engaged on that repair for three months, from the end of September to the end of December. The history of that cable is interesting because when the contractors laid it originally it failed. I think they were about three years in repairing it, notwithstanding all their appliances and the three ships that were sent out, and what was the sum it cost them we never knew. This repair of ours cost us £5,000, which makes a very serious hole in the small revenue which we enjoy. The expenditure on cable repairs this half year has made it important that we should draw on our stock, for which we had already contracted, and which has been hitherto lying with our contractors. After completing that work our ship had to go to resume the repairing of another break on the Jamaica-Porto-Rico section, but had to be recalled in order to proceed with other repairs on the Holland Bay-Ponce cable; but she is now on her way to England, and I hope she will be here in about 10 days from now, to take up the 250 knots of cable referred to in the last report, and will proceed to the West Indies to complete the repair of the original Jamaica-Porto-Rico cable. With regard to the ordinary expenses, over which we may be assumed to have some control, they offer no feature for any remark. There is no variation in them from former years. Coming to the issue of debentures, I am glad to say that we have

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speed, say N′, and measure the apparent increase of resistance of the coil, say σ', above its original value.

Then if $\frac{\sigma}{N} = \frac{\sigma'}{N'}$, the apparent increase of resistance obtained with either speed may be used, and the required coefficient of self-induction $= K\frac{\sigma}{N}$; if, on the other hand, $\frac{\sigma}{N}$ is larger than $\frac{\sigma'}{N'}$, then the speed N′ is too high, and possibly also is N, to give accurate results. Therefore use a speed N″ lower then N, and measure the new increase of resistance σ''.

If now $\frac{\sigma}{N} = \frac{\sigma''}{N''}$ the speed N was not too high to give accurate results, although N′ was; hence the apparent increase of resistance obtained with either speed N or N″ may be used, and the required coefficient of self-induction $= K\frac{\sigma}{N}$.

If $\frac{\sigma}{N}$ be only a little *greater* than $\frac{\sigma'}{N'}$ and if N′ *much exceeds* N, then it will not be necessary to make a third experiment at the lower speed N″ unless very accurate results are desired, for the coefficient of self-induction can only be a very little greater than $K\frac{\sigma}{N}$, which may therefore be practically taken as the correct value.

By the simple addition, therefore, of such a commutating arrangement as we have described to an ordinary Wheatstone bridge, it becomes possible, whenever the resistance of a coil electro-magnet, &c., is being measured, to measure also the coefficient of self-induction in absolute measure, by a zero method which is as sensitive for the measurement of self-induction as the ordinary Wheatstone bridge method is for the measurement of resistance.

From what precedes it follows that

$$L = K\frac{\sigma - \sigma''}{N - N''};$$

so that if s_1, s_2 be the apparent resistanees of the coil at two speeds, N_1, N_2 revolutions per minute, the speeds not being too large,

$$L = K\frac{s_1 - s_2}{N_1 - N_2};$$

hence *the coefficient of self-induction can be determined from two experiments made with the revolving double commutator without knowing the true resistance of the coil at all.*

If there be doubt as to whether the speeds N_1 and N_2 are too large, a third check speed, N_3, may be used; or instead, as explained in Appendix II., a rough test of the resistance of the coil for steady currents may be made; but time need not be spent in obtaining an accurate balance, as quite a rough balance can be used as follows:—Let O on the scale be the true zero for no current passing through the galvanometer, and let the spot of light be at, say, 156 divisions when an approximation is made to balance for steady currents, the resistance of the coil appearing to be s ohms, then the zero to be used in making the *second* and *third* tests just described is $l \times 156$, where l is the lead and σ is to be reckoned as the increase above the approximate value of the resistance for steady currents.

Commercial Forms of the Instrument.

The long-range instrument previously described requires an electromotor to drive it, and a speed-indicator to register its speed, hence it would be too cumbersome for everyday work. Further, as it is very difficult to maintain the absolute constancy of the speed of a small motor driving a friction brake, like our commutating arrangement, at a high-speed for any considerable time, in consequence of very slight variations in the friction of a high-speed brake producing marked variations in the speed, it requires two experimenters to use the form of our instruments already described; one to vary the resistance until the galvanometer needle comes to zero, and the other to note the speed of the motor at the moment that the first experimenter gives a signal that the galvanometer needle is at zero.

Hence, in the autumn of last year, we were led to consider what form should be given to the commercial instrument to be used for the measurement of self-induction in this way. The main condition of the problem was that the instrument should be able to be used by one experimenter *alone*, since one experimenter alone can measure a resistance with a Wheatstone bridge, and therefore we felt that if another experimenter had to be summoned when a coefficient of self-induction had to be measured, the instrument would lose much of its practical value. Our first idea was to employ clockwork that would drive the commutating arrangement at various fixed speeds, determined by the adjustment of a certain powerful governing arrangement, and to this end commutators of very small diameter were constructed, so as to waste only a small amount of power in friction and interfere but little with the action of the governor. The problem at first sight appeared an easy one, but the experiments of one of our assistants, Mr. Bourne, whom we have to thank for the many ingenious devices that he has suggested, and for the skill that he has brought to bear in the construction of the various experimental forms that the apparatus has passed through in its development, showed that in consequence of the high speed of the commutator, and of its acting as a friction brake, good results could only be obtained with clockwork of such unwieldy dimensions as to make it impossible for the instrument to be made portable; further, it was contrary to our engineering instincts to employ an apparatus which wasted so large a portion of the power required to drive it in the governing arrangements.

When making the experiments with the original commutating apparatus, two methods suggested themselves of obtaining a balance—the one, to try and to keep the speed of the electro-motor nearly constant, and to vary the resistance of one of the arms of the bridge, by trial, until the galvanometer needle came to zero; the other, to commence by increasing one of the arms of the bridge by a definite amount, and to vary the speed of the electro-motor, by trial, until the galvanometer needle came to zero; and it soon appeared that the second method was the one that would have to be adopted in a practical instrument, since, while it is very difficult to maintain a constant speed, there is no difficulty in obtaining a gradually diminishing or increasing speed. For example, the apparatus may be provided with a fly-wheel having a large amount of inertia, and may be driven by hand more or less fast until the galvanometer needle comes to zero. The next step in order to avoid the necessity of a second experimenter was to devise a *recording speed-indicator*, and the best form that we have arrived at is based on the principle that we employed in constructing an apparatus some years ago for experiments on centrifugal force, described at a meeting of the Physical Society at the time, and in regular use in the mechanical laboratory of the Finsbury Telegraph College ever since, for experiments on centrifugal force.

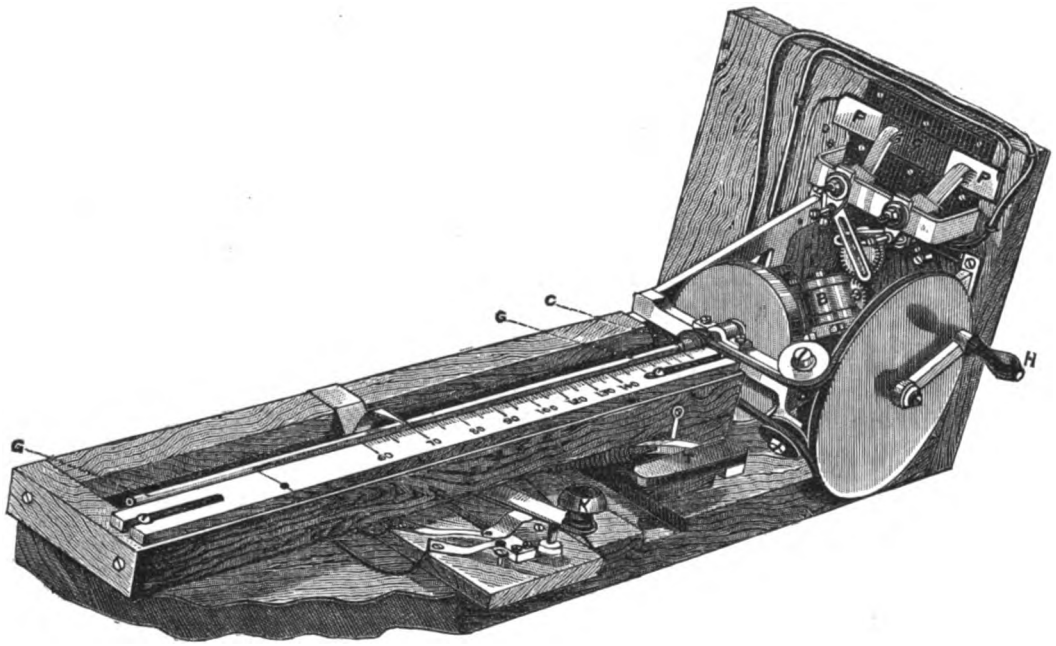

Fig. 5.—Experimental Secohmmeter.

Attached to the commutation of our self-induction apparatus is a box, B (Fig. 5), fitted with weighted elastic sides made of corrugated steel, which fly out more and more under the action of centrifugal force, as the box is rotated faster and faster. A stout glass tube, G, of comparatively small bore, open at both ends, is cemented into a collar in the axis of the box, and rotates with the box. The box is completely filled with mercury, and the tube partially, hence the volume of the box expands as its sides fly out and the length of the column of mercury in the tube diminishes, so that the length of the column at any moment is a measure of the speed of rotation of the box. In the neck of the collar, C, in which the tube is cemented, there is a steel tap attached to an axial spindle passing through a tube inside the box, and projected out of this tube at the other end of the box. If this spindle be turned relatively to the box, the

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tap is opened or closed. At the commencement of an experiment the tap is opened, and the handle H is turned with the right hand, faster and faster, until, on depressing the key K with the left hand from time to time, the galvanometer needle is seen to be approaching zero, or the spot of light the zero position on the scale. The key may now be kept depressed, and on turning the handle a little faster a speed is at length reached producing exact balance—if the handle be turned faster, the needle or spot of light deflects to one side of the zero, if more slowly to the other—at this moment the trigger T is lightly touched with the left hand and a spring is liberated. This has the effect of producing a resistance to the rotation of the tap-spindle, which previously was rotating freely with the rotating box, and the tap is thus turned off, cutting off the connection between the mercury in the glass tube and that in the box. Consequently the mercury in the tube remains, even after the instrument is stopped, of exactly the same length that it had when the trigger was touched. *The position of the end of thread of mercury in the tube is now read off on the scale attached, and the apparent increase of resistance of the coil, electro-magnet, or whatever it may be, divided by the number on the scale, gives the required coefficient of self-induction in second-ohms without any further calculation.*

The instrument is therefore *direct reading.*

This first form of recording speed-indicator was designed to be used vertically, as may be seen from the figure, but we soon found that great advantages were to be gained by placing it *horizontal*. If the glass tube be vertical the mercury in the tube exerts a pressure on the elastic sides of the box, which diminishes as the mercury falls on the speed of rotation being increased. This diminution of pressure causes the mercury not to fall so much for a given speed as it would were there no variation in the pressure due to the mercury in the tube, and so it diminishes the sensibility, hence we have been led to employ a horizontal tube. Further, since the mercury in a horizontal tube exerts no pressure on the elastic sides of the box, the amount of mercury in the tube does not in any way affect the sensibility, provided that the scale is so placed that the zero is opposite the end of the thread of mercury when the box is at rest. Hence, should any spilling of the mercury by accident occur when the instrument is moved about, the accuracy of the readings is not altered, so that by placing the tube horizontal we obtain greater sensibility and constancy in the readings.

Variations in the temperature from day to day cause alterations in the volume of the mercury, and so alter the length of the thread of mercury in the tube, but this also introduces no error in the experimental result, nor difficulty in using the instrument, since before the commencement of the experiment the scale is slightly moved until the zero on it comes opposite the position occupied by the end of the thread of mercury on the day in question when the box is at rest.

At first, rotating commutators similar to those shown in Fig. 1 were employed with the apparatus shown in Fig. 5; next the brushes were made of a variety of different forms, so as to press *radially* on the rotating commutators to prevent the wear altering the lead, and thus changing the sensibility of the instrument; but this form of commutator has at length been entirely superseded by the two oscillating arms, or brushes, A, A, worked by a cam. Each arm is composed of several pieces of hard copper, contact being made through the ends, as in many of the switches now used for electric light work. The end of each brush alternately rubs on a flat piece of phosphor bronze, P, P, when it makes contact, and on a *flat* piece of glass or agate, *g*, when it does not. This form of commutator we found superior for our purpose to the double cylindrical one, since, with the two oscillating arms, the lead can be more easily varied for adjustment; and this slight adjustment of the lead, we may here mention, forms the fine adjustment in the construction of this direct reading instrument. Further, the slow wearing of this form of brush does not alter the lead, consequently the value of the graduations of the scale remains constant.

The lead aimed at in the construction of these instruments is $\frac{1}{4}$, as that gives an equal time to each operation, but in any actual instrument it may be made a little more or less than $\frac{1}{4}$, being slightly altered, as just explained, in the final adjusting of the instrument by the maker.

It might appear, at first sight, that the two ends of an oscillating lever, or the two prongs of a vibrating tuning fork, would perform the required makes and breaks in the right order, but a reference to the cycle of operations given in the table, page 18, and a little consideration will show that the two prongs of a tuning fork cannot perform the required cycle of operations in the correct order.

Following the precedent of naming an instrument after the name of the unit employed—for example, "ammeter," "voltmeter," "ohmmeter," "wattmeter"—it seems desirable to call this instrument after the name of the commercial unit of self and mutual induction. The absolute electromagnetic unit of self and mutual induction is one centimetre, a name used by all scientific nations. But the commercial unit of self and mutual induction is $99,777 \times 10^4$ centimetres, or second-ohm, which is a little less than 10^9 centimetres, or one earth's quadrant. Now, in spite of the difference between these two numbers, which, although small, it is a pity to lose sight of, the English word "quadrant" is not used in French, therefore it would not be well to suggest this word as the international name for the unit. Yet it is most important that some name should be universally adopted, since the use of simple familiar names has much to do with making people familiar with the laws of the effect measured by the unit. The unit of electrostatic capacity, the farad, has been called after the greatest experimental worker in electricity; it would, therefore, seem appropriate that the unit of electromagnetic capacity should be called after Maxwell, the greatest mathematical worker in electricity. We do not, however, like to propose this, as we feel there might be difficulty in obtaining the general acceptance of the name of an Englishman, however great, unless it were sanctioned by an international electrical congress, or unless the man's name was intimately associated in men's minds with self and mutual induction. And Maxwell's large contribution to the subject of electromagnetic induction is surrounded by his equally large contributions to all other branches of electricity and magnetism—a giant surrounded by giants is not prominent. Coming to the last two years, we are glad that the leader and all those who have followed him in taking part in the widening of our ideas in self-induction are still with us. Hence we are driven to suggesting a temporary name for the unit, and as the first three letters in "second" are common to the name in English, French, German, Italian, &c., and ohm is also common, we venture to suggest "*secohm*" as a provisional name, and our instrument we will therefore call a "*secohmmeter.*"

(To be continued.)

FIFTY YEARS' PROGRESS IN TELEGRAPHY.*

By W. H. Preece, F.R.S., Vice-President of the Society.

This is the Jubilee year of the electric telegraph in England. On July the 25th, 1837, the first practical trial of telegraphy was made between Euston and Camden, on the London and North-Western Railway, by Cooke and Wheatstone. Nine tedious years were spent in endeavouring to create enthusiasm among financial circles for this young and novel means of communication. The first company formed to develop the business of transmitting and delivering written telegrams was incorporated in 1846, and was called the Electric Telegraph Company. Wires were speedily extended to every great centre of trade along the great railways that were then being developed, and about 1851 the business was fairly established. Telegraphy and railways have grown up side by side. In 1851 submarine telegraphy was proved to be practical. Cables were laid in 1852 and 1853 to France, Belgium, Holland, and Ireland, and from that year domestic and international telegraphy grew and prospered. The Electric Telegraph Company suffered the fate of all prosperous initiators of that which is novel, useful, and successful. The validity of their patents was contested, the strength of their business was assailed all along the line by enterprising competitors. Their monopoly was broken, but the public gained by this active rivalry greater development of communication and considerable reduction of rates. We see the same process going on at the present day with respect to telephones, but with less success.

The rates for messages, which were as high as 12s. 6d. for twenty words, were based on a sliding scale. The rates for a message of twenty words were fixed at 1d. per mile for distances under 50 miles, then ½d. per mile up to 100 miles, and ¼d. per mile for a distance of more than 100 miles; addresses forming part of the twenty words. A message to Glasgow cost 8¾d. per word, to Manchester 5$\frac{1}{20}$d.

Various reductions took place from time to time. In 1864, that is in less than twenty years, three great companies competed in every principal town for this profitable business of telegraphy. The United Kingdom Telegraph Company was formed in 1861 to introduce the universal shilling rate; but the severity of the competition of their opponents was too great for this spirited company, and they had, in 1865, to submit to the following general tariff:—Within London and other towns, 6d.; within 100 miles, 1s.; within 200 miles, 1s. 6d.; over 200 miles, 2s.—addresses being sent free.

The public now began to suffer. Only the larger towns, where profitable business could be tapped, were served. The smaller towns were neglected, and great villages had to suffer the aggravation of seeing posts and wires pass through their main thoroughfares without being able to avail themselves of this speedy mode of communication.

Telegraphy became a necessity of the age for the due and proper transaction of business. It became so closely allied with other modes of communication that public opinion, in 1868-9, forced the Government to purchase and absorb all the telegraph companies, and to transfer their business to the care of the Post Office, which had shown itself so capable in dealing with letters and newspapers, and in establishing the penny post.

The telegraphs of this country again became a great monopoly; but there is a vast difference between a monopoly in the hands of a private speculative corporation, subject to no control but that of its own closed ring, and whose sole object is to earn dividends or to make money, and that in the hands of the Government, whose sole object is to serve their masters, the public, faithfully and well, and whose actions are incessantly supervised by the jealous and watchful eyes of those they serve, who have an equally watchful and much less tolerant press in which to air their wrath and grievances, and an active House of Parliament ever ready to counteract and reform real abuses when fairly and properly laid before it.

It is impossible to conceive supervision more complete than that to which the Post Office is subject. The receiver of every letter, the transmitter of every message, the editor of every paper, the reader of every news despatch, every householder or business man, can see for himself how his own business is conducted; he can growl and grumble to his heart's content at any error or delay that may occur, with a certain knowledge that his complaint has been heard, and, if just, remedied, although he may not always be satisfied with the attention he receives. The telegraphic business of this country has reached its present dimensions because the work has been done well, and it has been done well because the mode of doing the business has been so well and so thoroughly supervised by the public.

The transfer of the telegraphs to the State took place on February 5th, 1870. The tariff established by Parliament was a uniform tariff of 1s. for twenty words, addresses being sent free, and this tariff remained in force until October 1st, 1885, when the present simple word tariff of ½d. per word, irrespective of distance, and including addresses, with a minimum of 6d., was introduced.

The average cost for the transmission of a telegram immediately before the transfer was 2s. 1¼d. After the transfer it was reduced to 1s. 1d. It is now 8d.

* Paper read before the Society of Arts, on Wednesday, May 18.

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The number of offices open to the public prior to the transfer was 2,932, but owing to the existence of three large companies in the same town, the number of towns in telegraphic communication was probably not more than 2 500. There are now 6,514 offices open to the public. [See Appendix I.]

But the amount of business done is a better criterion of the benefits that the public have derived from the transfer of the telegraphs to the Post Office. At the close of the year 1870 the gross receipts of the Telegraph Department were £612,301; at the close of 1886 they were £1,787,264, and at the close of this year they will probably reach £1,950,000. The number of messages transmitted in 1869 were 6,000,000; in 1870 they were 9,850,177; in 1880 they were 26,547,137; in 1886 they were 39,235,813; and at the end of this year (1887) they will probably exceed 52,000,000. [*Vide* Appendix II.] Diagram I. exhibits graphically the rate of growth of messages and wires, and it illustrates pointedly the result of the ½d. per word tariff, whose success has exceeded all estimate and anticipation.

The development of telegraphy is better shown in our great central station than anywhere else. The following Table is interesting:—

Date.	One day's messages.	Instruments.	Staff.		
			Male.	Female.	Total.
Before transfer..	8,500	...	...	...	...
1870.....	12,000	350	280	485	765
1880.....	43,000	486	826	598	1,424
1886.....	98,570	945	1,490	802	2,292

The number of messages dealt with each day ranges from 70,000 to 100,000, nearly half of which are transmitted messages which have to be both received and forwarded, and therefore become, practically, two messages, although they count as only one in the total.

The local traffic in London—that is, messages emanating from one part of London for delivery in some other part, and passing through the central station—is very large. It ranges from 12,000 to 18,000 messages per day. In 1868 there were 60 offices open in the metropolis, dealing with 300 messages per day; there are now 480 offices, dealing with an average of 15,000 messages a day.

The total number of local metropolitan messages for four weeks was:—February, 1870, 138,534; January, 1880, 726,199; January, 1887, 1,277,838—a tenfold growth nearly.

Press Arrangements.

One of the great objections raised against the absorption of the telegraphs by the State was the difficulty which the Government would have in transmitting news. In no country is there now such a complete system of telegraphy for news purposes as there is in the United Kingdom. Two complete news circuits serve always (day and night) the following important centres from London:—

1. Newcastle, Edinburgh, Glasgow, Dundee, Aberdeen.
2. Nottingham, Sheffield, Leeds, Bradford.
3. Birmingham, Manchester, Liverpool.
4. Bristol, Gloucester, Newport, Cardiff, Exeter, Plymouth.
5. Brighton, Portsmouth.
6. Dublin, Cork, Belfast.
7. Northampton, Leicester, Derby.

There are several other groups in the provinces served from these centres, and every evening after six p.m. a third, and frequently, especially in the Parliamentary Session, a fourth circuit is made up to all these stations from London. Each office on each of these groups receives simultaneously the news sent from London. Thirty newspapers obtain the use of special wires, with clerks' services, from 6 p.m. to 6 a.m., many, like the *Scotsman*, the *Newcastle Chronicle*, and the *Manchester Guardian*, having two circuits; and whenever any great political event arises, such as the delivery of a great speech, all the important towns throughout the kingdom receive simultaneously a *verbatim* report of the speech. There is not a town in the country where a daily paper is printed which is not placed, after 6 p.m., in direct communication with London, and which does not deposit on every subscriber's breakfast table a nearly *verbatim* report of the previous night's debate in Parliament.

The press rates are very low. The average price paid is a little in excess of 2d. per 100 words. This entails a loss to the department roughly estimated at £200,000 a year, which is the amount the public is taxed for the support of the press. It is doubtful whether Parliament knew when it passed this low rate that it virtually meant a subsidy to the press. The loss might be very materially diminished if there were less competition and more union among newspapers and news agencies. As it is, the same matter has frequently to be sent twice over the same route, and the amount of unnecessary news sent, and therefore unnecessary expense incurred, is enormous, much of it finding its way into the waste paper basket. The supply of news before the transfer was very meagre. Reuter's telegrams, Parliamentary reports, general news, markets, races, were supplied for £200 a year. The companies did this jointly, and news was collected as well as distributed; but the Post Office is simply a carrier. It is not allowed to collect, and it has thus saved much of the obloquy that attached to the irresponsible monopoly of the telegraph companies. The average number of words supplied to each newspaper was said to be 4,000 a day. It is now roughly estimated at about an average of 12,000 in the recess, and 15,000 or 20,000 in the session.

The following will give some idea of the total number of words sent on one evening, on important political occasions, from the central station:—

April 8th, 1886.—Mr. Gladstone's Home Rule Bill, 1,050,500 words.

April 16th, 1886.—Land Purchase Bill, 841,500 words.

June 7th, 1886.—Irish Government Bill (Division), 863,700.

Appendix III. shows how rapid and great has been the increase in this branch of our business.

Apparatus.

It is perhaps in the character and form of the apparatus used to transmit messages that the greatest progress has been made. It is difficult to say whether increased business has led to better apparatus, or whether beautiful apparatus has led to large business. One thing is certain that the better the work is done the more is business encouraged, and work cannot possibly be well done if the apparatus used for discharging that business is inefficient or backward. When the Post Office assumed the control of the telegraphs, it amalgamated in to one department an incongruous combination of various systems, worked by differently trained staffs, due to the various companies having been formed at different periods to inaugurate different patents. The Electric Telegraph Company established the needle system of Cooke and Wheatstone, the printing system of Bain, which merged into that of Morse, and the various improvements patented by Varley; the Magnetic Company fathered the magnetic system of Henley and the bell system of Bright; the British Company introduced the system of Highton; the United Kingdom Company promoted the beautiful type-writer of Prof. Hughes; and the Universal Private Company was established to introduce the simple A B C system of Wheatstone.

We had telegraphs that appealed to the eye like the needle, those that appealed to the ear like the bell, some recorded signals in ink like the Morse, others printed their characters in bold type like the Hughes. Some were slow but simple like the A B C, others were fast but complicated like the automatic. Time and patience were needed to consolidate into homogeneity this heterogeneous collection of telegraphs and telegraphists. Some years elapsed before the doctrine of the survival of the fittest was asserted.

Now, in 1887, the predominant feature of our telegraphs is the simple sounder and the fast speed automatic recorder. Reading by sound is confined almost exclusively to the United Kingdom and to the United States. In Europe there is scarcely a sounder outside our islands. This is very remarkable for the sounder is simpler, more expeditious, and more accurate, than any other key system. Those who have been educated to regard a record as an element of accuracy can only be convinced by actual experience that it is an element of error, and this experience they will not seek. The argument they use against its adoption, viz., its liability to error is the very reverse of the fact.

Comparative Return, showing the Number and Description of Telegraph Instruments in the United Kingdom.

Year.	Automatic.	Sounders	Printers.	Needles.	Bells.	A B C's.	Miscellaneous.	Total.
1877...	164	1,294	1,692	3,680	210	4,572	129	11,741
1878...	167	1,380	1,560	3,495	277	4,641	859	12,376
1882...	224	2,000	1,330	3,791	313	4,398	2,035	14,091
1886...	384	3,181	1,368	4,003	388	3,883	5,179	18,386

During the past ten years a complete revolution has been effected in the quality and manufacture of our instruments. Exact measurement and scientific principles have supplanted rough and ready methods. Complete specification and rigid inspection have replaced cheap and nasty competition. The workmanship of a good telegraph instrument is to be rivalled only by that of a chronometer. Technical training has converted the workshop into a scientific laboratory.

The rapid increase of business that resulted from the uniform shilling tariff soon led to the erection of more wires, and the multiplication of wires soon attracted attention to methods of duplexing and quadruplexing the circuits. The duplex system means a mode of sending two messages in opposite directions at the same time. This was shown to be possible by Gintl, in Vienna, in 1853, but the necessity for such a system did not arrive until 1872, and as at the moment a want is felt something is sure to turn up to supply this want, so when duplexing was needed Mr. Stearns arrived from America with a well worked out practical system that was at once adopted, improved, and perfected. Still further congestion arising, quadruplex working, or the art of sending four messages on one wire at the same time, became desirable, and a practical quadruplex system, due to Mr. Edison, was imported in 1877 from the same inventive and practical region, the United States. Later on, in 1885, a still further development was matured in America, viz., the multiplex system of Delany, by which six messages can be simultaneously sent, which we have adopted, and the main features of which I now show you in action. The chief reason why these systems have been matured in America is that the want has been experienced there before here. Neither system was invented in America—each was invented in Europe. There are other wants that have been experienced here before there, and those who have visited the States have found that English inventions are equally appreciated and adopted there. It is in automatic telegraphy that we have made the greatest advances. The following table illustrates the progress made.

	Words per minute.	Speed to Ireland.
1870	80	50·3
1875	100	70
1880	200	150
1885	350	250
1887	450	450

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This increase has been due not only to improvement in the design of the apparatus, but to the steady examination of every defect and its removal, in the instrument and on the line. It would require a paper of itself to narrate the ten years' conflict with electro-magnetic inertia, static induction, climatic influences, and battery defects. The table tells the result of this conflict, and the battle is not yet over; and diagram I. shows how scientific methods and improved apparatus have checked the rate of growth of wires, and have made cheap telegraphy possible. There still exists in our system a potentiality of expansion. We are now attacking the wires. Copper is replacing iron on our poles, with very advantageous results. Its better conductivity, and its entire freedom from electro-magnetic inertia, give it an immense superiority over iron. Its greater price per ton is compensated by its lesser weight per unit resistance.

We are also examining and testing various modes of laying wires underground, with a view to attaining greater speed of working, which hitherto has checked the establishment of underground work.

One consequence of the introduction of these advanced systems of working has been the necessity to educate the operating staff in the scientific and technical details of the business. The absence of technical knowledge in all branches has hitherto been a great difficulty to surmount. The technical examinations inaugurated by this society, and continued by the City and Guilds Institute, have been most beneficial, but the most successful incentive has been the selection and promotion of those who have given their attention to their own scientific education. This evident necessity for technical knowledge is reacting on the higher Post Office officials, and one finds all over the country a healthful spirit of inquiry arising—a striving after something better than the mere perfunctory discharge of official duties. There is something so captivating in the development of the practical applications of electricity, that those who make a study of it, especially experimentally, find in it more real enjoyment than any puzzling over the vagaries of the modern poet, or poring over the meaning of ancient cynics. A successful experiment is a distinct revelation—an admission into courts where, according to Bacon, are found "secrets not dangerous to know, sides and parties not factious to hold, precepts not penal to disobey."

(To be continued.)

PHYSICAL SOCIETY.—May 14.

Prof. W. E. AYRTON, Vice-President, in the chair.

Mr. T. Mather was elected a member of the society.

The following papers were read:—*On a Modification of a Method of Maxwell's for Measuring the Coefficients of Self-Induction*, by E. C. RIMINGTON. The method referred to is given in Maxwell's "Electricity and Magnetism," § 778, Vol. 2, and is called "Comparison of the electrostatic capacity of a condenser with the electro-magnetic capacity of a coil." The apparatus used consists of a Wheatstone bridge having the coil in one, and the condenser as a shunt to the opposite, arm. In order that no deflection may be produced, either for steady or unsteady currents, a troublesome double adjustment of the resistances is necessary, and to obviate this the modification was devised. It consists in placing the condenser as a shunt to only part of the arm, and this part can be varied by sliding contacts without altering the whole resistance of the arm. An ordinary resistance balance for steady currents is first obtained, and the sliders are then adjusted until no deflection is produced on breaking the battery circuit. Under these circumstances, it is shown that $L = K r^2 \frac{D}{B}$, where K is the capacity of the condenser, r the resistance between the sliders, and D and B the resistances of the arms in which the coil and condenser are placed. The conditions of maximum sensibility are investigated, and also those under which a telephone may replace the galvanometer; in the latter it is shown that the only possible solution is when $r = B$, *i.e.*, Maxwell's arrangement. The author believes his modification would be made much more sensitive by adopting the "cumulative" method used by Profs. Ayrton and Perry in their secohmmeter, and in his case neither the speed nor the "lead" need be known. Mr. W. N. SHAW asked whether any serious difficulties were experienced with telephones, owing to electrostatic capacities of wires. &c., and Mr. W. E. SUMPNER pointed out that the particular arrangement given in Maxwell is not always the most positive, as was shown in his remarks at the last meeting of the Society of Telegraph-Engineers. Mr. BOSANQUET thought the method a valuable one, and hoped many experiments would be made on coils whose coefficients were calculable, in order to find out the differences between calculated and observed results. Prof. AYRTON referred to the recent paper by Prof. J. J. Thompson in the *Philosophical Transactions*, and pointed out that the formula there given for the capacity of a condenser in electromagnetic measure is identical with that given in Maxwell § 776, when the printer's error of interchanging a and a in the denominator for R_2 is corrected.

On a Magnetic Potentiometer, by A. P. CHATTICK, read by Prof. REINOLD. The so-called magnetic resistance between two points on a magnetic circuit may be expressed as the ratio of the difference of potential to the total induction passing from one to the other (provided there be no magnetomotive force between them). From the fact that the volume integral of induction through a wire helix of constant cross section is proportional to the average difference of potential between its ends, it follows that any alteration in that difference of potential will give rise to an E.M.F. in the helix proportional to that alteration. Hence, if the wire be connected to a ballistic galvanometer, the combination may be called a magnetic potentiometer. A helix is formed by winding wire uniformly on a piece of solid indiarubber or canvas gas tubing of constant cross section, using an even number of layers to avoid external inductive effects, and leaving a small space between the turns, so as to allow the tube to bend without elongating. Experiments made to measure the difference of potential between the ends of a magnet gave satisfactory results. One end of the helix was held stationary at one end of the magnet, whilst the other was moved quickly to the other end of the magnet, and the resulting throw of the galvanometer observed. This was next done at two operations, and the sum of the two throws was very nearly equal to the first. The results can be reduced to absolute measure by passing the helix through a coil of n turns, bringing its ends together, and starting or stopping a current C in the coil, the resulting throw of the galvanometer being noticed. The magnetomotive force used in this experiment is $4\pi n C$. An interesting discussion followed, in which Prof. PERRY, Mr. SHAW, Prof. AYRTON, and Mr. BOSANQUET took part, the latter mentioning a measurement of magnetic potential made by himself some years ago. In consequence of the absence of Prof. S. P. Thompson, his paper on secondary generators was postponed till next meeting.

LEGAL.

Anglo-American Brush Company v. R. E. Crompton and Co.

This was an appeal from the order of Mr. Justice Kay directing a commission to the United States to take the evidence of Mr. C. F. Brush at the instance of the plaintiffs. We understand the appeal was in consequence of what the defendants considered to be insufficient affidavits on the part of the plaintiffs to justify a commission, but further affidavits having been filed stating further communications since the date of the order, the Court of Appeal declined to depart from the established practice in these cases and confirmed the order of Mr. Justice Kay.

COMPANIES' MEETINGS & REPORTS.

West India and Panama Telegraph Company (Limited).

The twentieth ordinary general meeting of the members of the West India and Panama Telegraph Company (incorporated 9th January, 1877) was held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, the 18th inst., under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the previous meeting, which the Chairman signed as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: Gentlemen, this time last year we had to announce to you that there was a falling off in the traffic receipts of a little over £2,000 for the last half of the year 1885. This half year our traffic receipts are practically the same as they were at that time. I think telegraph receipts are (political disturbances set aside, and there are no political disturbances in the West Indies) a very good barometer of the state of trade in any region that the telegraph serves, and therefore we may deduce from the circumstance that our traffic receipts continue to be the same as they were this time last year, that the same depression in the sugar trade exists now as it did then; indeed, the prices ruling in the sugar market confirm this view. We find that sugar, which generally speaking used to be worth £1, is worth now only 11s. to 12s. per cwt., and I need not say that the sugar industry causes the chief source of our revenue. At the same time we have been very unfortunate in the matter of repairs, a circumstance which we cannot control. The movements of the sea, the earth, and the winds are beyond human control, and they affect our cables sometimes very prejudicially. This half year we have had twelve cables interrupted, while in the corresponding period of last year we had only ten interrupted. The length of cable used has been in excess of that required during the corresponding period of last year. We had one very long piece repaired in the Jamaica-Colon section after prolonged and costly operations, owing to the great depth of water in which it lay. As stated in the report, the cable was recovered finally at a depth of 1,613 fathoms. The ship was engaged on that repair for three months, from the end of September to the end of December. The history of that cable is interesting because when the contractors laid it originally it failed. I think they were about three years in repairing it, notwithstanding all their appliances and the three ships that were sent out, and what was the sum it cost them we never knew. This repair of ours cost us £5,000, which makes a very serious hole in the small revenue which we enjoy. The expenditure on cable repairs this half year has made it important that we should draw on our stock, for which we had already contracted, and which has been hitherto lying with our contractors. After completing that work our ship had to go to resume the repairing of another break on the Jamaica-Porto-Rico section, but had to be recalled in order to proceed with other repairs on the Holland Bay-Ponce cable; but she is now on her way to England, and I hope she will be here in about 10 days from now, to take up the 250 knots of cable referred to in the last report, and will proceed to the West Indies to complete the repair of the original Jamaica-Porto-Rico cable. With regard to the ordinary expenses, over which we may be assumed to have some control, they offer no feature for any remark. There is no variation in them from former years. Coming to the issue of debentures, I am glad to say that we have

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had offers to take up the whole of those that are unissued. When we first issued those debentures the market was in rather an unfavourable position. Money was tight at the beginning of the year, and our shareholders did not come forward in the way that we expected; but we made a very satisfactory arrangement with our bankers, and have been borrowing the money to make up the deficiency of £12,000 at the bank rate, which has fallen to a low figure now, being only 2 per cent., so that in fact we have made a good thing by these debentures not being taken up. By placing these debentures at 5 per cent. there will be a saving of £500 a year to the Company. The fifth paragraph of the report refers to a scheme which has given us some anxiety and trouble, namely, the proposal of the French Government to connect the Brazils with North America, touching their West India colonies, Martinique and Guadeloupe. I want to ask what on earth can France want by going to the other side of the world to connect two points with a cable where she has no very great interest? It puzzled us enormously when the project was first mooted. The matter was discussed in the Chamber of Deputies on two or three occasions, and it seemed to us a ridiculous thing that the French Minister of Posts and Telegraphs should seriously debate the question, and ask the Chamber to give a grant of £40,000 to any telegraph company for the construction of such a cable. Fancy what would have been the result if our Secretary of State for the Colonies had asked for £40,000 a year for a similar purpose. I think that the scheme has fallen through for the present, and I hope it will not again be entertained. I think a great many of the members saw that they really had no call to spend £40,000 a year on connecting the very small colonies that they had got there, more especially since two of the most important of them are already served by the existing company, and the traffic from them is quite insignificant. I do not know that I have anything more to say to you; but I shall be very glad to answer any questions that shareholders may like to ask. Our future depends very much upon the condition of the West Indies. We cannot control Governments or the forces that are under the earth. They can both affect us prejudicially. When a Government subsidises sugar production anywhere it can do an enormous injury to other sugar-producing colonies. But it is not our business or within our power to alter such a condition of affairs as that. Then, again, the forces under the earth are the cause of the great loss that we have sustained in the category of expenditure, and I cannot hold out any hopes, seeing the region in which our cables are laid, that we may not again be the victims of the violence of the hurricane or the action of the volcano. He concluded by formally moving the adoption of the report and accounts.

Mr. WM. FORD seconded the motion.

Messrs. GRIFFITH, VEARS, THORNE, CUFF, and PARKER having addreesed the meeting,

The CHAIRMAN said: We have divided amongst you now upwards of £200,000, and kept your telegraph system in a perfect state. When the present Board were called in to take the management of the concern it was in a condition of absolute collapse. Mr. Griffith, I think, made some remarks as to the increase of the ships' expenditure in harbour over that when they are in port. That is an obvious mistake, because there are no coals consumed in port. Of course the ships are maintained in a state of readiness to go away at a moment's notice, and the fixed expenditure is the same, but there is no cost for coal. As to our getting contractors to maintain our cables, I think it would surprise you to know, if you approached them with such a suggestion, how much they would charge. The most moderate tender that you would get would take away the whole of your revenue. We know very well what contractors expect for such a business as that, and at such a distance from home. I do not think anybody would entertain it. As to the issue of debentures, we do not intend to issue them at a discount, nor to give any commission on them. I do not think it is necessary for me to reply to the remarks of Mr. Parker. I have said what the position of the Directors in this concern is over and over again. As you know, under the old Board, a committee of shareholders was formed to inquire into the circumstances of that Company, and as a result the present Directors were elected by the committee, and they had no interest in the inception of this unfortunate affair. Certain terms were proposed to them, and you got the most experienced men in telegraphy in this country to manage your business, and you agreed to pay them for their services. That is all I can say on the matter.

The resolution was then put to the vote, and it was carried with two dissentients.

On the motion of the CHAIRMAN, seconded by Mr. HOLMES, Mr. W. Andrews was re-elected a Director of the Company, as was also Sir James Anderson on the motion of the CHAIRMAN, seconded by Mr. W. FORD.

Mr. ANDREWS and Sir JAMES ANDERSON having duly returned thanks for this renewed mark of the confidence of the shareholders in them,

Mr. VEARS proposed the re-appointment of the auditor, Mr. John G. Griffiths, F.C.A., which was seconded by Mr. WM. GRIFFITH, and also agreed to.

Mr. VEARS then proposed a vote of thanks to the Chairman and Directors, which was seconded by Mr. HARLAND, and the proceedings terminated.

London Platino-Brazilian Telegraph Company (Limited).

Report of the Directors to be presented to the shareholders at the ninth ordinary general meeting to be held at the offices of the Company, Winchester House, 5C, Old Broad-street, E.C., on Monday, 23rd May, at twelve o'clock:—

The net revenue of the year, after providing for debenture interest and income-tax, is £13,026. 9s. 4d., and £1,171. 7s. 4d. is brought in from the preceding year's account, making a total of £14,197. 16s. 8d. to the credit of revenue account. The interim dividend of 2s. per share, paid on the 22nd November, 1886, absorbed £3,834. 16s., leaving therefore to be dealt with £10,363. 0s. 8d, from which the directors propose to appropriate £150 in further reduction of the item of expenses of issue of the Six per Cent. Debentures, to add £1,000 to the reserve fund, and to apply £7,669. 12s. in payment of a final dividend of 4s. per share, making, with the interim dividend already paid, a distribution at the rate of 3 per cent. per annum (as against 1 per cent. paid last year), leaving a balance of £1,543. 8s. 8d. to be carried forward. The directors are pleased to be able to state that the accounts show a marked increase in the receipts from the land lines in Uruguay. It is satisfactory also to find a considerable increase in the amount received from the Western and Brazilian Company in respect of the cable system. The difference between that company and this has not yet been adjusted, and this Company's claim remains unsettled. The submarine cables and land lines are in good working order. According to the Articles of Association, John Hollocombe, Esq., a director of the Company, retires by rotation, and offers himself for re-election. Messrs. Deloitte, Dever, Griffiths and Co., the auditors, also retire at this meeting, and offer themselves for re-election.

CITY NOTES.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 13th inst. were £3,707.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th May are £2,287, as compared with £2,767 in the corresponding period of 1886. The January receipts, estimated at £5,735, realised £5,807.

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED).—The Jablochkoff and General Electricity Company has been joined by Messrs. Manville and Madgen, and the name of the company has been changed to the United Electrical Engineering Company (Limited). We understand that the company will shortly bring out a new type of arc lamp, and will also make a speciality of secondary generators under Jablochkoff's patent.

APPOINTMENT.—The Telegraph Manufacturing Company of the Britannia Telegraph Works, Helsby, near Warrington, have appointed Mr. Alfred Whalley to be their London representative for telegraph, telephone and electrical signalling apparatus. The company contemplate opening a depôt in London; meantime Mr. Whalley's address is No. 2, Whitehead's-grove, Chelsea, S.W.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 18.		BUSINESS DONE WEEK ENDING MAY 18. Highest.		Lowest.
Anglo-American	36½,	37¼	..... 36½	.....	36
Do. Preferred	59,	60	..... 59¾	.....	59
Do. Deferred	14½,	15½	..... 14¾	.....	14¼
Brazilian Submarine	10¾,	11¼	..... 11¼	.....	10⅞
Cuba	12,	12½	..... —	.....	—
Do. Preference	18,	19	..... 18¾	.....	—
Direct Spanish	2¾,	3	..... —	.....	—
Do. Preference	7,	8	..... —	.....	—
Direct United States Cable	9,	9¼	..... 9¼	.....	9
Eastern Telegraph	10⅝,	10¾	..... 10¾	.....	10 9-16
Do. 6 per Cent. Preference	13¾,	14¼	..... 14¼	.....	—
Do. 5 per Cent. Debentures, 1899	106,	109	..... 107½	.....	—
Eastern Extension	11⅛,	11¾	..... 11¾	.....	11 9-16
German Union	10½,	11	..... 10⅝	.....	10½
Globe Telegraph and Trust	5⅛,	5¾	..... 5⅝	.....	5 9-16
Do. Preference	12⅜,	12¾	..... 12¾	.....	12½
Great Northern	13⅜,	13¾	..... 13¾	.....	13 11-16
Indo-European	34,	35	 34	.....	—
Reuter's	7¾,	8¼	..... 8¼	.....	7 15-16
Submarine	180,	190	..... —	.....	—
West India and Panama	⅝,	¾	..... —	.....	—
Do. 1st Preference	9½,	9¾	..... —	.....	—
Western Brazilian	7¼,	7½	..... 7¼	.....	7¼
Western Union 7 per Cent. 1st Mortgage	120,	125	..... 122½	.....	—
Do. 6 per Cent. Sterling Bonds	102,	105	..... —	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	..... —	.....	-
Oriental	3-16,	5-16	..... —	.....	—
United Telephone	13¼,	13⅜	.....13 11-16	.....	13⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅞,	3⅛	..... 3⅛	.....	2⅞ ex new
Do. (fully paid)	4,	4½	..... 4¾	.....	4⅜ ex new
Swan	1⅜,	1⅝	..... —	.....	—
Maxim Weston	3-16,	5-16	..... —	.....	—

MISCELLANEOUS.

Telegraph Construction	36,	37	..... 36½	.....	36
India Rubber, Gutta Percha, and Telegraph Works	23,	24	..... 23½	.....	23

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NOTES.

SECONDARY BATTERY QUESTIONS IN BRUSSELS.—In reply to the letter of "Interested" on the above subject, our Brussels correspondent will write further on the subject in our next issue.

NEW YORK.—An annual saving of $15,000 has been effected by the substitution of electric light for gas in the New York General Post Office. The present system of lighting costs $45,000 per annum.

TRANSFORMER PATENTS IN GERMANY.—The German Patent Office has finally refused to recognise the claims of Zipernowski, Déri, and Blateny for the use of a closed magnetic circuit and the coupling of transformers in parallel.

GUADALAJARA, SPAIN.—Guadalajara, a town of 8,000 inhabitants, is to be lit on the Zipernowski-Déri system, motive power being obtained from a turbine capable of developing 40 horse-power at a distance of two miles from the town.

PROJECTED CABLE BETWEEN TUNIS AND MARSEILLES.—The French journals announce "under all reserve" that their Government has under consideration a project for laying a submarine cable between Tunis, Bizerte, and Marseilles. An annual subvention of 100,000 francs is spoken of.

THE "ENGINEERING" DIRECTORY.—We have received a copy of a useful trade list, published and circulated gratuitously by the proprietors of *Engineering*, and which consists of a classified list of the names and addresses of advertisers in that journal, together with a separate list of their telegraphic addresses.

CHICAGO.—The American *Sanitary Engineer* states that the gas and electric light companies of Chicago have been amalgamated under the title of the Gas Trust Company, which will now control all the lighting of the city. It is intended chiefly to develop electric lighting, and several new plants will be erected for this purpose.

A RASH EXPERIMENT.—We regret to note that a fatal accident has occurred in New York to a man named Simpson, who was in charge of a dynamo machine at the Adams Express Building, Broadway. It appears that Simpson purposely laid hold of the terminals of the machine in order to show some visitors how much current he could stand.

TELEPHONING BETWEEN BRUSSELS AND HAVRE.—Since the completion of the line between Paris and Havre conversations have been held between the latter place and Brussels, the distance being about 350 miles. The articulation is said to have been very nearly as good as in the shorter line.

TELEPHONE CONTRACT OPEN.—The Haslingden Local Board require tenders for the construction of a line of telephonic communication between the fire station at the Public Hall, Haslingden, and the Waterworks Office at Rawtenstall. Specifications and forms of tender can be had of Mr. T. Woodcock, clerk, Public Hall, Haslingden. Tenders must be received by 12 noon on 2nd June.

PROGRESS OF THE ELECTRIC LIGHT IN JAPAN.—At Tokio, Japan, a company, with a capital of £40,000, has been formed to supply the electric light from central stations. It is proposed to establish five centres in Tokio, two at Osaka, two at Nogoya, and one at Kioto. The company has received an order to supply the Imperial Palace with current for 2,000 incandescent and 100 arc lamps for their first central station.

MEXICO.—We are sorry to learn that the citizens of Mexico have just been treated to the novel spectacle of a bull fight by electric light. An immense crowd thronged to the Colon Plaza to witness it, President Diez and several members of his Cabinet figuring among the spectators. The sport was particularly "good," the unfamiliar glare having had the effect of rousing the bulls to an unusually high pitch of fury.

"ANNUAIRE DE L'ELECTRICITÉ."—We have received a copy of the fifth annual issue of the "Annuaire de l'Electricité." For those who are not acquainted with this useful publication we may mention that its contents consist of a brief directory of the electrical trades and professions for each country of Europe, together with information concerning the various Government services and learned societies, &c., connected with electricity.

A FERRIC-CHLORIDE CELL.—Mr. H. N. Warren, writing in the *Chemical News*, states that for zinc carbon cells an exciting liquid superior to bichromate of potassium may be made by taking a strong solution of ferric chloride, slightly acidified, and mixed with bromine (in what proportion does not appear). The bromine serves to reoxidise the ferrous chloride formed, and when consumed may be again set free by the addition of bleaching powder.

NIAGARA FALLS.—It is stated that the Buffalo Electric Light Company has entered into a contract with the Niagara Falls Hydraulic Tunnel and Power Company to take 10,000 horse-power, at 15 dollars per horse-power per annum, for lighting the city and manufacturing purposes. The route for the proposed cable has been surveyed from Niagara Falls, a distance of twenty miles. Negotiations are also pending for lighting and supplying power to other towns in the vicinity.

THE TELEPHONE IN THE FRENCH ARMY.—Since the year 1882, when the telephone was first employed in the French army, during the field manœuvres, much attention has been paid to its development, especially for out-post service. Magneto instruments, dispensing with batteries, are exclusively employed, and a special telephone corps is now being organised, which will have an organisation distinct from that of the military telegraphs, its purpose being, in fact, wholly different.

AN ELECTRIC WATER HEATER.—The German Edison Company is selling an electric water heater for heating shaving water, boiling an egg, or making coffee, &c., &c. It consists simply of a metallic vessel containing an inner casing within which is placed a coil of German silver. A litre of water can be made to boil in twelve minutes with a current of four amperes and 100 volts, and at a cost of about 2d., according to the tariff at present in force at Berlin. The convenience of such an apparatus is so great that its introduction in all cases of central station lighting is probably a mere question of time.

OBITUARY.—We regret to announce the death, at Kirkcaldy, on May 15th, of Mr. James Townsend, local manager to the National Telephone Company in their Scottish South Central District. Mr. Townsend was an electrician, and more especially a telephonist, of great promise, and much esteemed by his employers and by all who knew him. Deceased was elected an Associate of the Society of Telegraph-Engineers and Electricians only about six weeks ago. He was assistant honorary secretary to the East of Scotland Naturalist Society, and the author of several papers on electrical subjects read before that body

CONVERSAZIONE OF THE INSTITUTE OF CIVIL ENGINEERS.—The annual *conversazione* of the Institute of Civil Engineers was held on Wednesday last at the South Kensington Museum. The guests were received by Mr. Woods (the president of the institute) and Miss Woods, and upwards of 3,000 invitations were accepted. In addition to the inexhaustible artistic attrac-

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tions of the museum, a series of entertainments, musical and otherwise, were held in the lecture theatre, and two recitations were given by the ever-popular Mr. Corney Grain. In the North Court the string band of the Royal Artillery played a selection of music.

LIVERPOOL AND MANCHESTER TELEPHONIC COMMUNICATION.—Telephonic communication between Liverpool and Manchester was interrupted from Friday to Monday last, owing to the fall of a large tree, which broke down the lines near Wigan. The numerous inquiries which resulted from the accident afford an evidence of the extent to which inter-urban telephony now enters into the commercial life of the northern towns. We imagine that if London were entirely cut off from telephonic communication with neighbouring towns, even for a week together, no one would find their equanamity much disturbed thereby.

THE USE OF THE DYNAMO MACHINE IN TELEGRAPHY.—It is well known that several years ago this arrangement was successfully carried out in Calcutta by the late Mr. Louis Schwendler. Since then Dr. Liego has introduced the system at New York, where several of the telegraph companies now work their lines from a dynamo. Upon the suggestion of M. Picard a similar plan is now being tried in the central telegraph office at Paris, and is giving entire satisfaction. It is said that fast speed Wheatstone instruments are worked as easily as the Hughes type writer or local single-needle circuits. The dynamo in use gives 120 volts.

ELECTRICITY AND SHIPBUILDING.—The steel screw steamer, "Albania," which was launched from the yard of Messrs. A. M'Millan and Son, on Thursday last, had the whole of her plates drilled and riveted by means of electro-magnetic machine tools, designed by Messrs. F. J. Rowan, C.E., and J. M'Millan, jun. We shall shortly give a full illustrated description of these machines. We may state that it is anticipated that the adoption of this method of drilling will lead to a possible reduction in the weights of the hulls of vessels, owing to the greater accuracy with which the work can be carried out. If this anticipation be realised the extra cost will be more than compensated without taking into account the saving of time and labour.

ELECTRIC LIGHTHOUSES AND THE CORK HARBOUR BOARD.—At a meeting of the Cork Harbour Board, on the 11th inst., a resolution was proposed and carried to the effect that the question of lighthouse illuminants should be re-investigated by the Trinity House. From the remarks of the speakers it appeared that most of them were under the impression that it had been conclusively proved that in thick weather gas had a greater penetrative power than electricity. But it should be noted that, although this statement was originally made on good authority, yet it has never received confirmation by subsequent observers. On this point we would refer those interested to the report of the French Commission, of which some account is given in another column.

THE DEPREZ-ABDANK ELECTRIC BELL SYSTEM.—The method of working electric bells devised by MM. Deprez and Abdank bids fair in time almost to supersede the use of the battery. The current is generated by the vibration of a coil of wire between the poles of a pair of small magnets, the coil being fixed on the end of a stiff blade-spring, which is set in vibration by a slight pull. The cheapness and simplicity of the method is obvious, while as to its efficiency we are informed that on a Continental railway the arrangement has been at work for a long while signalling over a distance of 600 miles. Much, however, as we appreciate the merits of this system, we have been not a little amused by the comments of the daily press, one of the journals winding up its account with the exclamation, "Surely an unexampled instance of scientific research!"

THE ENOS ELECTRIC RAILWAY.—The Enos electric railway is practically a development of the telpherage system invented in this country. There are, however, certain differences in detail which would naturally be made in the endeavour to adapt the system to passenger traffic. Thus, the conductors become stouter, and rest on an iron trestle supported by iron standards. The second rail is set underneath the first, and the car runs with one pair of wheels on the upper and one on the lower rail, the motor being placed in circuit directly through the car wheels. A street railway of this description is already in use at Los Angeles, California, and efforts are now being made to obtain permission to build a similar line in Boston. About twelve months ago we chronicled the experimental trial in the neighbourhood of Boston of an almost identical system, under the name of the Chandler Overhead Electric Railway.

PRIVATE VERSUS CENTRAL STATION LIGHTING.—We are sorry to find ourselves unable to agree with Herr Hegener when (according to the *Gas World*) he expressed the opinion that although a gasworks may possibly be upon good terms with a private producer of the electric light, yet a central electric lighting company must needs regard him as a mortal enemy. We venture to think, on the other hand, that the existence of any private electric lighting emphasises the demand and guarantees the ultimate success of central station lighting. If electric lighting is so much wanted that in numerous cases it is considered worth while by private persons to go to the trouble and expense of producing it for themselves, what is likely to be the demand when the current is brought to everybody's door? Meanwhile, it is certain that all prospective electric lighting stations owe a debt of gratitude to those individuals who are familiarising the public with the beauties and advantages of electricity as a lighting agent.

THE PABST TELEGRAPH BATTERY.—The *Revue Internationale* contains a glowing account of the merits of a new cell adopted for the telegraphic service, and introduced by Dr. Conrad Pabst. The negative element consists of a carbon plate, which is "prepared" in some way left unexplained with oxide of zinc. The positive element is a cubical block of iron. The solution consists of chloride of zinc, and one of the chief claims on behalf of the battery is that owing to the deliquesent properties of this salt no addition of water is ever required, provided that the battery be kept in a place not too dry and warm. Further than this, the element is said to be self-regenerative, acting by the absorption of oxygen from the air, so that it requires no other attention than the renewal of the positive plate at long intervals. The action of the battery would appear to depend upon the conversion of ferrous chloride into ferric chloride by absorption of atmospheric oxygen, the ferric salt becoming ferrous by contact with the positive element. The utilization of this reaction for the purpose of depolarisation is, we may observe, by no means a novelty, and will be found to be fully described on page 159 of the second edition of "Sprague's Electricity."

TELEPHONE ON THE BRAIN.—An American physician has (says the *St. James's Gazette*) made a terrible discovery about the telephone. He declares—and he backs his statement by figures—that the mortality among subscribers to the telephone is three times greater than among people who do not avail themselves of its dangerous delights. The diseases most fre-

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quently produced by the constant use of the instrument are cerebral, pulmonary, and nervous. Indeed, "telephonism" may be briefly described as over-excitement of the nervous system. Science may yet throw further light upon the matter; and in the meantime people who use the telephone had better console themselves with the reflection that the American doctor is probably a faddist. But, whatever may be the sanitary effect of talking to a box and listening at a table, there can be no doubt that the occupation is bad for the temper. The hideous rumblings from an invisible world, the indistinct murmurings which so often represent the voice of your interlocutor, and the vain attempts to get "switched on" to somebody, render conversation by telephone a robust exercise of the virtue of patience and of that sweetness of temper which (in the male portion of mankind at least) is usually so soon exhausted.

THE GERMAN EDISON COMPANY AND MESSRS. SIEMENS AND HALSKE, OF BERLIN.—The report of the Board of Directors of the German Edison Company contains an announcement of some interest. Reference is first made to the development of the company's business, and attention is called to the great difficulties against which it has had to contend, especially those created by the unjustifiable imitations of the incandescent lamp patent. Although five judgments have been delivered in favour of the Edison Company, a definite decision has not yet been arrived at. It is complained that in the meantime the patent has run more than half its time, and the competition, against which thoroughly energetic steps cannot be taken, is continually increasing. The Edison Company has for years been carrying on fruitless negotiations with a view to liberating itself from the crippling influence of the French Compagnie Continentale. This state of affairs drew the Edison Company towards the firm of Siemens and Halske, and has led to an extension of the contract already existing with that firm. The title of the Edison Company will now be changed to the "Allgemeine Elektricitäts Gesellschaft" (Universal Electric Company). It may therefore, we assume, be understood that the interests of the Berlin Edison Company will henceforth be closely identified with those of the eminent firm above mentioned. The directors recommend the payment of a 4 per cent. dividend, and propose to increase their capital from £250,000 to £600,000.

LIVERPOOL AND TELEGRAPHIC DELAYS.—A feeling of dissatisfaction, says a local journal, on the part of Liverpool merchants, on the score of extraordinary delays in the telegraphic service between that city and the Continent, found expression on the 24th instant in a large and influentially attended public meeting, over which Sir William Forwood presided. Illustrating the delays in question, Sir William said it was found quicker and more convenient to send telegrams for Bremen and Havre round by New York than to entrust them to the direct service of the postal authorities. Mr. Hemelryk moved and Mr. W. D. Heynes seconded the following resolution, which was unanimously passed: "That this public meeting of merchants, brokers, and manufacturers of the city of Liverpool desires to bring under the notice of Her Majesty's Government the serious inconvenience and loss sustained by the trade of the port in consequence of the great delays which continue to exist in telegraphic communication with the Continent, and to protest against the dilatoriness of the postal authorities in removing the disabilities under which the trade is suffering." A further resolution, moved by Mr. H. Coke, and seconded by Mr. Blessey, was passed, urging the Postmaster-General to appropriate special wires for the convenience of messages from Liverpool direct to the Submarine Cable Company's offices in London, and suggesting an alteration in the system of registration of foreign telegrams at the London Post Office, to which much of the delay complained of is ascribed.

DR. ARON'S INTEGRATING AMPERE-METER.—Dr. Aron, of Berlin, some time ago devised an ampere-meter, based upon the principle adopted by Profs. Ayrton and Perry in their original watt-meter, in which the retardation of a clock pendulum indicated the expenditure of power. In Dr. Aron's instrument for measuring current (or volts) the bulb of the pendulum is replaced by a permanent magnet, and below this is placed a coil traversed by the main current. The pendulum is therefore subject to acceleration when the current passes. By comparing the time of this clock with standard time, and multiplying by a constant, the amperes or volts are integrated. The instrument has the obvious defect of depending upon the constancy of a permanent magnet, and when that magnet, as in the present case, swings to and fro in a variable field, it seems doubtful whether the calibration will long hold good. However, Dr. Aron, without altering this feature, has recently effected certain improvements in the construction, which are thus described in *Industries*:—"There are two pendulums, one with a magnet, the other with a common bulb. Each actuates its own escapement, and by a train of planet wheels the differential motion is registered on a dial similar to that of a speed counter or gas meter. Dr. Aron has also added a magnetic catch, which arrests both pendulums when no current is flowing, and releases them when one-tenth of an ampere or more is passing. By this addition the interval for rewinding the clock has been increased to about four weeks for average work."

"CROOKES' AMPERE-METER."—The heat-indicating paint devised some time ago by Mr. Henry Crookes has, we believe, already found a useful application in the engine room for the indication of hot bearings, and most probably for other similar purposes. We cannot, however, think him well advised in attempting to utilise the properties of this paint for the construction of an "ampere-meter." The utmost service which such an instrument could possibly render would be to indicate the passage of a current through a thin wire included in the circuit, but to attempt to measure the current by this means is obviously out of the question. However, Mr. Crookes shall describe the apparatus in his own language. "The instrument consists," he says, "essentially of a flat coil of thin wire, painted with heat indicating paint, and a screen round it, coated with ordinary red paint of the same shade. Coils of thick wire are placed in parallel circuit with the thin wire, and their resistances are so adjusted that by setting a commutator the point at which the indication of an excess of current takes place can be varied to suit different requirements. When an electric current is passed through the instrument the thin wire becomes warm, and when the current exceeds a certain quantity the temperature is raised sufficiently to change the colour of the paint to black, thus warning the man in charge that an excess of current is passing. On the current being reduced the temperature of the coil falls, and the paint returns to its original red colour." It will be seen from this that Mr. Crookes considers the instrument likely to be of use where a constant current has to be maintained in the circuit.

THE COREA.—PUTTING UP AN INSTALLATION UNDER DIFFICULTIES.—We mentioned some time ago that the King of Corea had ordered an extensive electric lighting plant from an American firm. The installation consists of 300 Edison lamps, and was first brought into use on February 20th, the anniversary of the birthday of the King's mother-in-law. A

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clause in the contract stipulated that the American workmen engaged in putting up the apparatus were to be amenable to the Corean code of justice. This was a somewhat severe proviso, inasmuch as it is enacted that if any foreigner looks upon the face of the Monarch of Corea or of his Queen, even by accident, he shall forthwith be put to death, and that without mercy. However, the royal pair were good enough to restrain their curiosity during the presence of the workmen, and palanquins were provided in which the men were carried through the corridors of the palace, heralded by trumpeters, whose blasts gave notice to the King and Queen to keep out of the way. So far the story is amusing, but it is with sincere regret we have to record the death of Mr. W. M'Kay, the chief electrician of the party. After escaping the factitious dangers of an intrusion on the royal presence, Mr. M'Kay was accidentally shot on March 9th while explaining to a native the mechanism of a revolver. The man was immediately seized and would have been beheaded by order of the King had not Mr. M'Kay been able before he died to explain that the occurrence was purely accidental. After his death the Corean was again seized, and was only released on the urgent entreaty of the wife of the victim, to whom, moreover, he had only recently been married.

Electric Lighting at the Civil Service Bread Company's Bakery.—The Gülcher Electric Light and Power Company, of Battersea Foundry, Battersea, S.W., have just completed the lighting of the new factory built by the above company at Horseferry-road. The electric light has been adopted throughout the whole of the premises, and the installation consists of a No. 2 Admiralty type Gülcher dynamo machine, fitted with a heavy turned fly-wheel, which is driven through counter shafting from the 14 horse-power Otto gas engine used for driving the main line shafting. The dynamo has been placed upon a very solid foundation built with cement, and with a stone 6ft. long and 3ft. 6in. wide by 15in. thick, placed on the top, to which the dynamo is bolted. The current from the dynamo is first led to a main switch-board, which consists of a slate slab 3ft. 6in. long by 2ft. wide, supported in a wooden frame. This board carries 12 sub-circuit switches, and the current passes through 12 adjustable resistance coils. The installation consists of eight 2,000 candle-power Gülcher arc lamps and twenty-one 16 candle-power incandescent lamps. Each arc lamp is fitted with the company's patent rope gripper, which prevents the lamps accidentally slipping, and also avoids the necessity of in any way coiling up or fastening the lowering cord. The incandescent lamps are suspended by silk flexible cords, fitted with ceiling roses, cut-outs, and 10in. opal reflectors. The whole of the cables throughout the installation are run in continuous troughing, and every precaution has been taken to make the installation as complete in all its details as possible. The work has been carried out under the superintendence of Mr. Mountain, the general manager of the Gülcher Company.

The Electric Light and the Continental Gas Companies.—Some few weeks ago a rather singular step was taken by a syndicate of gas companies on the Continent. With a laudable desire to arrive, if possible, at some definite conclusion as to whether the time had yet come when electric lighting could be profitably combined with the manufacture of gas, it was determined to establish an electrical laboratory in which the question could receive a practical study from the point of view of the gas interest. The syndicate included the gas companies of Paris, Marseilles, Lyons, Madrid, and other places. The exact purpose and range of the experiments to be undertaken has not been made known, nor is it very clear what are the outstanding questions which the gas companies could hope to decide by experiments upon a laboratory scale. However, the syndicate was fortunate in securing the services of M. Monnier, who was at one time connected with the Marseilles Gas Company, and who is now Professor of Electricity at the Ecole Centrale of Paris. We have learnt with a good deal of interest that M. Monnier has already arrived at some very tangible results, of which we shall hope to hear further before long. The *Moniteur de l'Industrie du Gaz*, in a recent issue, made the following announcement:—"M. Monnier has obtained some marvellous results in connection with the electric light, and it is certain that the gas companies and the financiers for whom he is acting will not be slow to avail themselves, wherever a favourable opportunity exists, of the movement which has now established itself in favour of this mode of lighting." It is at least clear that the gas companies abroad are inclined to take a more intelligent and enlightened view of the subject than appears to be the case at present with those of our own country.

Lighting of No. 7, Stratton-street, Piccadilly.—The Gülcher Electric Light and Power Company have just completed the lighting of Lord Wolverton's town residence, in Stratton-street, Piccadilly. The installation, on account of the small space at the disposal of the contractors, was a somewhat difficult one to undertake, but has been most successfully completed. The plant consists of a 2 horse-power Otto gas engine, placed in the cellar under the road, the exhaust being led into a large exhaust chamber, and taken to the top of the roof by a much larger pipe than is usual. The engine bed foundation, consisting of a stone slab, is supported on two thicknesses of thick felt, these precautions being taken to avoid any chance of noise or vibration. A No. 1 Gülcher shunt-wound dynamo, fitted with a 2ft. diameter turned and balanced fly-wheel, is driven from the fly-wheel of the engine, and charges 27 Elwell-Parker accumulators, supported in varnished wooden trays, carried upon four oil insulators. In the dynamo and engine room a special switch-board is fixed, with which the following operations can be performed without any possible chance of short-circuiting or otherwise damaging the installation by switching on the wrong switches: 1st movement charges accumulators; 2nd movement discharges accumulators through the lamps; 3rd movement runs dynamo and accumulators in parallel; 4th movement runs lamps direct from the dynamo; 5th movement cuts lamps, dynamo, and accumulators out of circuit. On the left-hand side of the board a 5 contact switch is placed, enabling 5 extra cells to be added as the E.M.F. falls; measuring plugs for measuring the E.M.F. or current in any circuit are arranged on the same slate slab, also a voltmeter. This board was designed by Mr. Mountain. The fittings for the house throughout are of an artistic character.

Electric Lighthouses in France.—The last issue of the *Abstracts of Papers in Foreign Transactions and Periodicals*, published by the Institution of Civil Engineers, contains a translation of the report of the special commission appointed by the French Government on electric lighthouses, with especial reference to the question of flashing or scintillating *versus* steady or slowly revolving lights. There are at present existing seven electric lighthouses on the French coast, of which all but two give rapid flashes on a system devised by M. Allard. The commission arrived at the general conclusion that "*electric lights have greater illuminating power than oil lights for all weathers and at all distances*; and the report concludes with the expression of the following opinions;—"The disposition of electric scintillating

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lights inaugurated by M. Allard, and applied on the coast of France, has advantages over all other systems of illumination employed hitherto in France or elsewhere. It seems to be almost faultless, optically and mechanically, and as nearly perfect as possible in the present state of knowledge. It may therefore be adopted, without modification (until further orders) in future installations of electric lighthouses in France. It will be expedient, however:—(1) Not to use the reserve oil lamp until means have been found of making it maintain distinctly the characteristic of the electric lamp. (2) To reduce to a minimum the dust from the burning carbons, and to protect from it the mechanism of the electric lamps, and of the revolving machinery of the optical apparatus. (3) To renounce the use of double power, until improvements of the apparatus allow of resorting to the ensuing increase of luminous intensity, which indeed is of little practical use. (4) To avoid, especially for landfall lighthouses, the introduction of a red flash among white flashes. The development of electric lighthouses should be carried on, in the first place, by their establishment at proper landfalls, and in the order of importance of these for navigation, namely:—Ouessant, Belle Ile, Barfleur, Mouth of the Gironde, Ile d'Yeu, Penmarch. Before proceeding further, the results of experience to be furnished by these lights should be awaited."

PROPOSED ELECTRIC LIGHTING ON THE LEES, FOLKESTONE.—The following is a summarised report of a discussion which took place on Wednesday last at a meeting of the Folkestone Town Council:—The Town Clerk said he had received additional correspondence as to the electric lighting of other towns. At Eastbourne the length of the frontage was 1,530 yards, which was lighted by sixteen arc lamps on the Brush system by the Hammond Electric Company at £400 per annum all the year through, from an hour after sunset to half-past 11 at night. The contract was terminable at three months' notice on either side. The company found all the plant, and kept it in repair, except damage arising from storms. The power of the lights was 1,000 candle nominal. The Mayor said they would require gas after half-past 11 at night, and he wanted to find out the hours such a proposal as that at Eastbourne would give them. He understood that the lighting by gas at present gave an average of ten hours per night throughout the year. Mr. Thompson said the time at Eastbourne would be an average of four hours per night. The Lees was nearly the same length as the frontage at Eastbourne. He calculated that the distance was about five-eighths of a mile. The Town Clerk said at Hastings the length was three-quarters of a mile, the contract was for three years, and the light was much appreciated. It was on the Brush system. There were fifteen arc lights of 2,000 candle-power, and the cost was £450 per annum. At Norwich, where electric lighting had been introduced, they gave it up four years ago, as it was not to be depended upon, and was double the price of gas. Mr. Thompson said at Dundalk, a small town, they were lighted by twenty-four arc lights of 3,000 candle-power for three years at £400 per annum. They had no lighting in June, end of July, and three days at full moon in every month, so that it could be put down at £600 for the whole of the year. It was considered there to effect a saving of £60 per year as compared with gas. Mr. Payer said next week he should move that tenders for lighting the Lees be invited. Mr. Sanders considered it a waste of time, as the lighting rate should be quite high enough as it was. Mr. Thompson doubted whether they should ask for tenders before they had made up their minds to have the electric light in the town. He did not see what they wanted the Lees lighted for. The electric light would not bring a single visitor. They did not come there to see the electric light. He could understand it if the town was lighted altogether by electricity; but he could not see the advantage of having the Lees lighted by electricity. But though he should be glad to get more information on it, he should not support the resolution proposed by Mr. Payer until they had determined whether they were going to have the light or not. Mr. Sanders said some of them had electric light on the brain. Ultimately it was arranged to have the question on the agenda paper for Wednesday week.

THE HISTORY OF THE STORAGE BATTERY.—Dr. P. H. Vander Wyde contributes to the *Electrical World* of New York the following brief history of the storage cell, up to the year 1881:—

1800. Volta invents the voltaic pile, a battery consisting of two different metals and a liquid.

1801. Gautherot discovers that the electrodes through which a voltaic battery has been discharged become capable of producing a current.

1801. Erman discovers that the electrode connected with the positive pole, when disconnected from the battery, will return a positive current; in fact, he discovers what we now call the principle of polarisation.

1801. Ritter, observing the same facts, succeeds in decomposing water by means of the polarised electrodes, and then demonstrates the inversion of the currents.

1802. Ritter makes the first secondary battery, consisting of a pile composed of discs of a single metal, copper, separated by a liquid, which becomes charged by passing the current of a voltaic battery through it, and produces all the phenomena of the primary, decomposing water, heating and burning wire, giving sparks, shocks, &c.

1803. Ritter constructs secondary batteries with plates of large size, and compares the results with those of smaller size.

1803. Ritter finds that copper is not the best metal for secondary batteries, and experiments with tin, zinc, lead, iron, bismuth, brass, silver, gold and platinum. He finds the best results with carburet of iron and oxide of manganese.

1805. Izarn describes in his *Manuel du Galvanism* five or six modifications of secondary batteries.

1826. Nobili deposited peroxide of lead on lead plate by means of a primary battery.

1837. Schönbein demonstrated that plates thus prepared possessed the property of giving a current like a primary battery.

1842. Grove made his famous gas battery based on the observation that when platinum plates had been used for the decomposition of water by the current, they would, when the battery was disconnected, cause the gases to recombine and in doing this produce an inverse current.

1843. Grove used plates covered with peroxides of metals.

1843. Siemens uses carbon plates.

1843. Wheatstone makes a secondary battery of platinum plates covered with peroxide of lead and potassium amalgam.

1853. Siemens uses carbon plates covered with oxide of lead converted into peroxide by the current.

1859. Planté finds that lead is the best metal for secondary batteries, and covers the surface with the peroxide by means of the primary current.

1861. Kirchhof makes the batteries of alternate plates of spongy lead and peroxide; also proposes to store up atmospheric electricty from insulated lightning rods, or to use magneto-electric machines for this purpose.

1866. Percival uses metal plates covered with crushed coke and powdered lead in diluted sulphuric acid.

1869. He uses a positive electrode of amalgamated zinc and a negative of lead.

1879. D'Arsonval uses carbon plates covered by oxid of lead and manganese and zinc plates in a solution of zinc sulphate.

1881. Faure creates surprise by a battery claimed to give superior results, and occuping less than a cubic foot of space, charged by a very slow process of forming.

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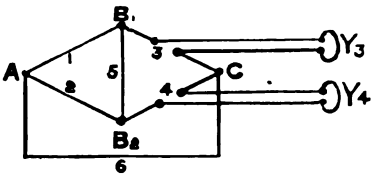
ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XXXIX.

BY OLIVER HEAVISIDE.

(Continued from page 6.)

This brings me to the subject of balancing rods against one another, either in the Christie or in the Felici differential arrangements, when placed in long solenoids; and to the similar question of balancing thick wires in the Christie, when the current in them is longitudinal. As I pointed out before (*Electrician*, May 30, 1886), if a wire be so thick that the effect of diffusion is sensible, it cannot be balanced in the Christie against a fine wire, but requires another thick wire in which the diffusion effect also occurs. I refer to true balances, independent of the manner of variation of the current, in which, therefore, the resistance of the one wire, though different at every moment, is yet precisely that of the other wire (or any constant multiple of it). Perhaps the best way to define the resistance is by Joule's RC^2. In the sinusoidal case a mean value is taken. According to this heat-generation formula, there always is a definite resistance *at a particular moment*, but what it may be will require elaborate calculation to find. This definition of the resistance to suit the instantaneous value of the dissipativity does not agree precisely with the sinusoidal R′, which represents a mean value; but the sinusoidal R′ has important recommendations which outweigh this disadvantage.



Suppose now we want to balance an iron wire against a copper wire, the wires being straight and long, though not so long as to require the consideration of electrostatic capacity. For simplicity, first let the ratio be one of equality, so that sides 1 and 2 in the Christie are any precisely equal admissible arrangements, which may be mere resistances. Let the iron wire be in side 3, the copper wire in side 4. We have to make side 3 an electrical full-sized copy of side 4. For definiteness, imagine Y_3 and Y_4 to be short-circuits, that one of the two parallel lines leading to either is the wire under test, whilst the other is a return tube, thin and concentric.

First, in accordance with the description of how to make copies (*Electrician*, March 11, 1887, p. 391), make the resistances of the two returns equal. Next, make the inductances due to the magnetic field in the space between wires and returns equal, by proper distance of returns, or by inductometers in sequence with sides 3 and 4. There is now left only the wires themselves to be equalised. First, their steady resistances require to be equal. Next, their steady inductances ($\frac{1}{2}\mu \times$ length). These two conditions will give balance to infinitely slow variations of current, and can be satisfied with wires of all sorts of sizes and lengths. But we require to make them balance during rapid variations of any kind. For, instance, a very short impulse will cause a mere surface current in the wires, that is, in appreciable strength, if they be thick; and still the wires must balance. The full balance is secured by a third condition, viz, that the time-constants of diffusion shall be equal. This time-constant is $\mu k \pi c^2$, where μ is the inductivity, k the conductivity, and c the radius of a wire. Or, $\mu l/R$, the quotient of the inductivity by the resistance per unit length (or any multiple that we may find convenient of this quotient).

Thus, if the iron has inductivity 100, that of copper being 1, whilst k for copper is about six times the value for iron, the copper wire must have a radius of about four times that of the iron. This is indispensable. Fixing thus the relative diameters, the rest is easy, by properly choosing the lengths. In a similar manner we may have the resistances in any proportion, as for instance, to obviate the necessity of having wires of very different lengths, keeping, however, the proper ratio of diameters.

The following will be more satisfactory as a demonstration. If Z is the V/C operator, then $Z_1/Z_2 = Z_3/Z_4$ is the condition of balance (*Electrician*, March 11, 1887). So we have merely to examine the form of the Z of a straight wire. This is (*Electrician*, July 23, 1886),

$$Z = L_0 p + Rf, \quad . \quad . \quad . \quad . \quad . \quad (31c)$$

where f is the operator given by

$$f = \tfrac{1}{2} sc \frac{J_0(sc)}{J_1(sc)}; \qquad s^2 = -4\pi\mu k p. \quad . \quad . \quad (32c)$$

L_0 is the inductance other than that due to the wire itself, and R is its steady resistance. Using this form of Z in our general equation of balance, we see that if we take $s_3 c_3 = s_4 c_4$, that is, make the diffusion time-constants equal, we make $f_3 = f_4$, so that the balance is given by

$$\frac{Z_1}{Z_2} = \frac{R_3}{R_4} = \frac{L_{03}}{L_{04}} = \frac{r_3}{r_4}, \quad . \quad . \quad . \quad . \quad . \quad (33c)$$

where the additional r_3 and r_4 are for the two return sheaths or other resistances that may be in sides 3 and 4. Of course Z_1 and Z_2 may be R_1 and R_2, the resistances of sides 1 and 2, when they are mere resistances. In virtue of the equality of the diffusion time-constants, we may express the full conditions by adding to (33c) this:—

$$= \frac{\mu_3 l_3}{\mu_4 l_4}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (34c)$$

where l_3 and l_4 are the lengths of the two wires.

Although this balance is true, yet there will be one practical difficulty in the way. As is very easily shown by sliding a coil along an iron wire or rod, the inductivity often varies from place to place. But if the wire be made homogeneous the evil is cured.

Next, let it be required to balance a long iron against a long copper rod in long magnetising solenoids forming sides 3 and 4. Here the form of Z for the circuit of the solenoid is

$$Z = R + L_0 p + L p f^{-1} \quad . \quad . \quad . \quad . \quad (35c)$$

where R is the total resistance (as ordinarily understood) of the circuit of the solenoid, L_0 the total inductance ditto, due to the magnetic field everywhere except in the core, L that due to the core itself when the field is steady, and f as before, in (32c).

To balance the iron against the copper we therefore require, first, the equality of time constants of diffusion, or the iron rod should be one-fourth the radius of the copper; this being done,

$$\frac{Z_1}{Z_2} = \frac{R_3}{R_4} = \frac{L_{03}}{L_{04}} = \frac{L_3}{L_4} \quad . \quad . \quad . \quad . \quad . \quad . \quad (36c)$$

will complete the balance. The value of L (*i.e.*, L_3 or L_4) is

$$L = (2\pi c N)^2 \mu l, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (37c)$$

if N is the number of turns per unit length, and l the length of the solenoid. As for L_0, that is adjustable *ad lib.* nearly. The only failure will be due to want of homogeneity.

Lastly, balance two rods, one of iron the other of copper, against one another in Felici's arrangement, when each pair of coils consists of long coaxial solenoids, making two primaries and two secondaries, properly connected together. Let R_1, R_2 be the total resistances of the primary and the secondary circuit, L_{01}, L_{02} the total inductances, not counting the parts due to cores, M_0 the total mutual inductance, not counting the parts due to cores, L_1, L_2, and M those parts of the inductances, self and mutual, of the first pair of coils, due to the cores, and l_1, l_2, m the same for the second pair. The equations of E.M.F. in the primary and secondary are then, if F and f are the two core operators, as per (32c), and C_1, C_2 the primary and secondary currents,

$$\left.\begin{aligned} e &= R_1 C_1 + L_{01} p C_1 + M_0 p C_2 + F^{-1} p (L_1 C_1 + M C_2) \\ &\quad + f^{-1} p (l_1 C_1 + m C_2), \\ 0 &= R_2 C_2 + L_{02} p C_2 + M_0 p C_1 + F^{-1} p (L_2 C_2 + M C_1) \\ &\quad + f^{-1} p (l_2 C_2 + m C_1). \end{aligned}\right\} \quad (38c)$$

The first terms on the right are the E.M.F.'s used in the solenoid circuits against their resistance, the two following terms taken negatively the E.M.F.'s of induction not counting cores, and the last two taken negatively those due to the cores. To have a balance, C_2 must vanish. The second equation then gives

$$M_0 + M F^{-1} + m f^{-1} = 0 \quad . \quad . \quad . \quad . \quad (39c)$$

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So $M_0 = 0$, or the mutual inductance of the circuits due to other causes than the cores, must vanish. Then, further,

$$F = f, \text{ and } M = -m \quad . \quad . \quad . \quad . \quad (40c)$$

So the diffusion time-constants of the cores must be equal, and the steady mutual inductance of one pair be cancelled by that of the other pair of coils, so far as dependent on the cores, as well, as before said, as dependent on the rest of the system. [When not counting cores is spoken of, it is not meant that *air* must be substituted. *Nothing* must be substituted.] The latter part is capable of external balancing. The former part to be balanced requires the value of

$$M = (2\pi c)^2 N_1 N_2 \mu l, \quad . \quad . \quad . \quad . \quad . \quad (41c)$$

when N_1, N_2 are the turns per unit length in the two coils of a transformer of length l, to have the same value for the two transformers.

The condition (39c) of course makes the primary equation independent of the secondary. It is then the same as if the secondary coils were removed.

This leads us to show the modification made in the equation of a transformer by the conductivity of its core. In (38c) we have merely to ignore the f terms, thus confining ourselves to one transformer, when the equations are given by the first lines. Now if the solenoids be of small depth, and there be no L externally, L_{01} and L_{02} become insignificant, and also M_0, provided the cores fill the coils. We have then

$$\left.\begin{aligned} e &= R_1 C_1 + F^{-1} p (L_1 C_1 + M C_2) \\ 0 &= R_2 C_2 + F^{-1} p (L_2 C_2 + M C_1) \end{aligned}\right\} \quad . \quad . \quad (42c)$$

which only differ from the equations when cores are non-conducting by the introduction of F. The first approximation to F is unity (when very slow variations take place). It may be written thus— $F^{-1} = A - Bp, \quad . \quad . \quad . \quad . \quad . \quad (43c)$

when A and B are positive functions of p^2, whose initial values are $A = 1$, $B = 0$. When the impressed force is sinusoidal, $p^2 = -n^2$, and A and B are constants. Then (42c) becomes

$$\left.\begin{aligned} e &= R_1 C_1 + (L_1 C_1 + M C_2) B n^2 + A p (L_1 C_1 + M C_2), \\ 0 &= R_2 C_2 + (L_2 C_2 + M C_1) B n^2 + A p (L_2 C_2 + M C_1), \end{aligned}\right\} \quad (44c)$$

From these, by elimination, we have

$$\frac{e}{C_1} = R_1 + L_1 R_2 \frac{B n^2 (R_2 + L_2 B n^2) + A^2 L_2 n^2 + A R_2 p}{(R_2 + L_2 B n^2)^2 + (L_2 A n)^2} \quad . \quad (45c)$$

showing the effective resistance and inductance of the primary as modified by the secondary *and* conducting core.

But it is very easy with iron cores, without excessive frequency, to make simpler formulæ suit. Let $z = \pi c^2 k \mu n$; then, if this is 10 or over (see *Electrician*, Feb. 4, 1887), we have

$$A = Bn = (2z)^{-\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (46c)$$

approximately, which may be used in (44c), (45c) at once.

In an iron rod of only 1cm. radius, and $\mu = 100$, $k = 1/10{,}000$, the value of z is one-fifth of the frequency. If of 10cm. radius, it equals twenty times the frequency. With large values of z we have

$$\frac{e}{C_1} = R_1 + \frac{l_1 n}{1 + 2 l_2^2 n^2 / R_2 (R_2 + 2 l_2 n)} + \frac{R_2^2 l_1 p}{(R_2 + l_2 n)^2 + l_2^2 n^2} \quad . \quad (47c)$$

if L_1, L_2, and M, when divided by $(2z)^{\frac{1}{2}}$ become l_1, l_2, and m. This gives the primary current. And

$$\frac{e}{C_2} = -\left(\frac{R_1 R_2}{2mn} + \frac{R_1 L_2 + R_2 L_1}{M}\right) + \frac{R_1 R_2}{2mn^2} p \quad . \quad (48c)$$

gives the secondary current.

We can predict beforehand what these should lead to ultimately, from the general property that a secondary circuit, at sufficiently high frequencies, shuts out induction, or tends to bring $L_2 C_2 + M C_1$ to zero, giving the ratio of the currents at every moment. The coefficients of p in (47c) and (48c) tend to zero, and the current in the primary to be the same as if its resistance were increased by the amount $R_2 L_1 / L_2$. The core need not be solid. A cylinder will do as well, since the magnetisation does not penetrate deep. It should, however, be remembered that although at low frequencies it is the core that contributes the greater part of the inductance, so that the rest is then negligible, yet when that due to the core actually becomes negligible, the rest becomes relatively important, and should therefore be allowed for.

(To be continued.)

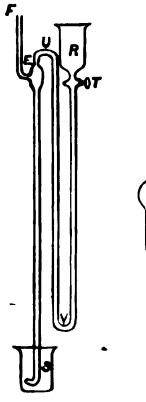
INCANDESCENT LAMP MANUFACTURE.—XV.

BY J. SWINBURNE.

Exhausting.

The next process is the most interesting, as well as the most difficult. Exhausting is generally done by the Sprengel pump, so it will be described first. The writer finds the Geissler pump preferable, as, if properly managed, it gives better vacuum, and is more easily worked. The reasons for this opinion will be given, and the experiments which led to it.

The Sprengel pump in its simplest form is described in most books on physics; but it is needless to remark that the Sprengel and Geissler pumps generally illustrated or commonly seen in physical laboratories would be of no use to the lamp maker. The essential part is a tube of small bore, down which mercury is allowed to fall in separate drops. The tube is so small that each drop forms a little plug or piston, which takes down any air in front of it. In practice the pumps have three or five of the fall tubes. Edison used to use, or still uses, a very simple form of single shaft pump; it is shown diagramatically in Fig. 11. It consists of a single fall tube with an elbow at E; the tube F goes to the lamp. Just above E the tube is contracted so as to make the mercury spurt through. R is a reservoir for mercury, T a tap to regulate the flow, and S gradually fills with mercury as the pump works. E is about forty inches above S. It will be as well to trace the action of this simple pump to show its defects, and to explain the problem that lamp makers have to deal with. It must not be supposed that Edison uses pumps with all these imperfections. The pump shown is a mere diagram; in practice it is made part of an automatic system. Suppose the lamp sealed on F, with a drying tube. R is filled with mercury and T is opened a little; the lower bend is filled with mercury, but the mercury cannot rise evenly in the two tubes, because air is imprisoned between the top of the mercury and the tap T. Every now and then the mercury will stop flowing, and will be pressed back, some bubbles of air thus escaping through R; this will go on till the mercury is nearly up to T. A little air will remain permanently below T, and the mercury will pour through in a thin stream which does not occupy the whole tube. The mercury will now rise in the tube U, and if the tube is of small bore it will run down to the contraction above E, pushing all the air before it. If the tube were of large bore the mercury would form a stream, and pour from U to E without expelling the air. This would render the pump useless, for as the vacuum was formed the air between U and E would expand, and every now and then a little would go through and spoil the vacuum. If the pump is properly made the mercury will fall past the tube F in separate drops, and each drop will form a little piston which pushes the air down in front of it. A single shaft Sprengel takes a long time to exhaust a lamp from the beginning; so in practice as much air as possible is removed by mechanical pumps before the mercury pump is started.



FIGS. 11 & 12.

Suppose the exhausting nearly complete, each drop of mercury falls about ten inches before it touches the column in the shaft. The points to be regarded in the arrangement of the contraction are, that the pump will exhaust as quickly as possible, and that it will do so with as little mercury as possible. The maximum speed is attained when one plug of mercury touches the top of the column in the shaft just as the next one reaches the contracted part of the fall tube. If the flow of mercury is increased, more plugs per minute go down the tube; but each plug takes down less air, so there is no advantage, and the mercury in R is used more quickly. If the reservoir R gets empty from any cause the mercury in the tube below the tap will fall about thirty inches. If the reservoir is now filled again the mercury will most likely take the air which is below the tap right round and spoil the vacuum. If the long bend V was not there at all the vacuum would be broken at once if R was

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allowed to get empty. The position of T is therefore wrong; it should be so low that the mercury cannot fall below it. It might appear at first sight that anywhere between V and U would do, but if the flow of mercury through the contraction is regulated by the tap there would be a partial vacuum above it, and the glass stopcock must be regarded as useful in preventing the mercury from coming out, but not to be relied on to keep air out. The tap should therefore be at the bottom of the bend V, so as to be under pressure, and the tube above it should be so large in bore that the mercury does not form plugs or imprison air. If the mechanical pump is used to start the vacuum there is no need for R to be above E, it need only be less than thirty inches below it. When the pump has been running some little time, air which has been sticking to the sides of the tube V U will come off and go round through E, spoiling the vacuum. To prevent this an air trap must be inserted in the upper part of the tube V U; this is shown in Fig. 12. Some put a little loose glass cup, shown dotted, inside the trap, so that it floats up and covers the end of the tube without closing it. The object is to prevent bubbles coming straight up the centre. Bubbles never do go up the centre of a long tube of mercury, as, if they once touch the side, they do not again go to the centre. Mercury does not wet glass. Such a trap as this would give trouble if the pump was not started by a mechanical exhaust, because it would contain a lot of air to begin with, and as the vacuum was produced this air would expand and go round U. If the trap is exhausted well before the mercury is admitted to it, there is no danger of a bubble of air getting round just as the process is complete. The air in the trap also acts as a sort of cushion, and makes it more difficult to regulate the flow of the mercury. Instead of the mercury coming through uniformly it stays above the contraction, while mercury flows continuously through the tap till the air is compressed enough to overcome the capillary attraction of the mercury for itself at the contraction at E. The mercury then flows through with a rush till the air is expanded, and stops again, and so on. The best way to avoid this is to have the reservoir R only a few inches above the level of E, and to make the contracted part of the tube of such size that it will work well with the tap fully open. Of course, this takes more mercury.

The best diameter for the fall tube is about one-tenth of an inch; a thick wall barometer tube is generally used. When the vacuum is good the little drops of mercury rattle down, and subject the tube to a series of little taps, due to the lateral pressure caused by the inertia of the mercury. After continued use most glass tube breaks just where the rattling takes place. Probably thin walled tube would be more durable, but it is difficult to get it uniform enough in bore to be of use. Springel tubes often present all sorts of curious fractures.

Care must be taken to put the connection for the mechanical exhaust in the right place. If it were made, say, at F, it would be necessary to seal the tube off every time, as no glass tap can be depended on. The joint must therefore be made between the top and U. When there is no vacuum in the pumps the mercury in V U will fall to the same level as that in the reservoir R, so the tube to the mechanical exhaust can be just above. Before turning on mercury a tap in the mechanical exhaust is opened, and the pump, lamp, and various tubes exhausted as well as possible. The mercury tap is then opened, and the mercury runs round into the fall tube and also runs thirty inches or so up the mechanical exhaust tube. The mechanical exhaust may be left on or not. If it is shut off, and the tap leaks a little, the air wil not get round into the lamp till the air inside the tube is nearly at the pressure of the atmosphere. If it is not shut off there is another danger, for if some other pump in the system is broken the air rushes in and spoils the vacuum of the mechanical pumps, and all the pumps connected with that pipe have their vacuums broken. If the lamps are not being "run on the pumps" this means loss of time and money, but all lamps that are running will be spoiled. The writer always shuts each pump off as soon as it is started, and inserts a globe between the tap and the pump, so that if the tube does leak a little it takes so long to fill the globe that the lamps are finished in safety.

CORRESPONDENCE.

ELECTRO-CHEMICAL EQUIVALENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Swinburne (p. 33) puts the real point at issue out of sight when he states my view as meaning that "electro chemists should not write thermo-chemical equations in the same way as other chemists." I am not aware that there is any absolute mode of writing thermo-electric equations as yet adopted; in fact, the whole subject of thermo-chemistry is in its infancy, and few chemists know anything much about it. The few authorities who deal with it use all sorts of units, calories per gramme, or units per lb. of substance, calories per equivalent, calories per molecule, &c. Even for chemical considerations, it would seem that the energy corresponding to the chemical equivalent would be more useful, because less confusing, than that of the modern molecule of varying equivalence, which requires a succession of arithmetical operations at every change of chemical constitution.

But is there really any law of science or common sense which requires us always to use the same expressions or symbols for substances when we are dealing with them for different purposes? Do we not find sulphuric acid written $SO_3 H_2 O$, $H_2 SO_4$, $\left.\begin{matrix} SO_2 \\ H_2 \end{matrix}\right\} O_2$, and perhaps half-a-dozen other ways—and every one of these rightly and usefully—as illustrating differing conceptions of the construction of the substance? We generally use the new notation and atomic values in our chemical writing, because they are now generally adopted, and cover a number of considerations which have chemical importance; but the old notation and equivalents have many advantages in practical chemistry, and no one can say that in course of time the chemists may not revert to them. In electricity, however, the equivalent notation is most certainly superior in intelligibility and practical convenience; the only reason against its use in electrical writings is the confusion which would arise from the use of two systems of chemical expression. As, however, the one thing absolutely certain in electrolytic reactions is the relation of unit electric quantity to unitary equivalents of substances, that relation is the fundamental one which our expressions ought to convey where possible. It hardly needs argument, therefore, to show that where we want to deal with the relation of energy to electrolytic reactions, we shall do best to connect our ideas with the absolute facts, with the real material equivalents which take part in the electric actions, not with the merely artificial symbols adopted to convey an entirely different set of chemical actions.

But the whole gist of the question is, what constant is the best to employ in the conversion of energy from one form to another, so as to show how the energy of chemical affinity is related to the energy involved in electromotive force? Should the constant be a single one, that related to the one equivalent of matter and one unit of electricity, or should it be variable with the constitution of the chemical molecules, containing one, two, three or more such equivalents? That is, shall the *constant* be a variable or not?

Mr. Swinburne says that the value I give "1 volt = 23,287·7 calories is, of course, inaccurate." I must really ask him not to bear false witness against me, and make me responsible for things I do not say. I did say "to speak of expressing volts in calories is absurd." I did give a value for something else, which value I expressly said was calculated for an "undetermined" electric unit of which no human being knows the real value, though our professors work it out to half a dozen decimal places, when they want to show something to suit their purposes. As he says, "of course" my figure may be inaccurate. In my letter, p. 7, I said, "in the present uncertainty I have reckoned." In my "Electricity," where all this subject is fully discussed, and where there are hundreds of calculations and many tables involved in it, I explained that I did not think it worth while to alter all this until the values of the various elementary data were finally settled. Meantime, the actual figures I give can be corrected to any value of any of the data preferred by a simple constant when desired. The figure 23,000, or thereabouts, in calories, is simply the equiva-

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lent, in the Gramme system, of the unit I proposed under the name of the *Equi-volt*, and described in the *English Mechanic*, 27th October, 1871. I there said, after working out the idea of the mechanical equivalent of the current doing one equivalent of chemical work under unit electrical conditions, "This result is of supreme importance, for it gives a definite meaning to the volt, which has hitherto been too ideal to grasp. It tells us that 'energy' equivalent to 4,673 foot-pounds exerted upon a chain, each link of which is an equivalent of matter, weighed in grains, converts that chain into an electric circuit under a tension of one volt at the source of the force."

As Mr. Swinburne does not know what a "volt-ohm-ampere-second" is, and that is the first step to realising the actual relation of volts and calories, I may explain that it is what is called a joule or joulad, the energy expended during one second, by an ampere current, in an ohm, under one volt of E.M.F. (this last is, of course, involved in the others, even if not expressed). When we know how many seconds an ampere-current requires to effect one equivalent of chemical decomposition, the two figures give us the equi-volt, the constant which expresses the relation between chemical energy and the electromotive force that energy can set up in a chemical reaction. The sum of the matter is simple; the potential energy of a chemical reaction, or that of the sum of a series of reactions, occurring in a circuit, can become kinetic, either as heat (expressible as calories or foot-pounds), or as electric work (calories or foot-pounds), and that electric work involves the setting up of an E.M.F. expressed in volts, which we know, as a matter of fact, is capable of generating that work in a unit circuit. The uncertainty of the actual value is due to the fact that we do not know exactly as yet what an ampere current is, how to get a real ohm, what we mean by a volt, the work value of the volt-ampere, or the exact mechanical equivalent of heat. We can as yet only recognise our knowledge as approximate, try to improve it, but still perceive that our errors of measurement do not affect the natural principles concerned.

Mr. Swinburne misses this when he says, "in the meantime H_2O stands for 18 grams of water, and however much we might like to call it 9 grams, we are not at liberty to call it so." That is not the pivot of the argument. We are not concerned about H_2O except when we want to deal with water itself. We are fixing the unit *ion* of electrolytic actions, and the question is whether we shall use the true natural one, the single atom of hydrogen, or double it merely because two atoms are taken up in the oxygen compound H_2O, while one suffices in HCl, and one suffices in a large number of electrolytes.—Yours, &c.,

JOHN T. SPRAGUE.

ELECTRIC LIGHTING TENDERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The thanks of all honest electrical engineers are due to you for your recent article on what you mildly term the discreditable episode at Southport. This case is by no means a solitary one, and I have myself come across several equally discreditable and equally disastrous in result. The Union Steamship Company invited tenders for their ship the "Trojan." The tenders duly arrived, and varied from the highest to the lowest in the proportion of about five to one. Now, the directors of that line are not electricians, but they are practical men, and, being such, they agreed amongst themselves that "something was wrong;" they did not understand what, but there was one clear way out of the difficulty, and that one they took. The project for lighting the ship was consequently abandoned.

Quite recently, in tendering for a supply of cable of a certain size and certain insulation resistance I was fortunate enough to hear what the tenders amounted to. I heard from the consulting engineer that the lowest tender—and, moreover, the one accepted—was 40 per cent. lower than the special net price quoted by a maker to us. Now, as that maker was not tendering, but knew that we were, it is impossible to arrive at any other conclusion than that the firm whose tender was accepted were considerable losers. They were determined *to get the work at any price.*

I could give other examples, and no doubt many others could do the same. The question is—How far is such a thing to go? Surrounded by numerous elephantine monsters, the Act of 1882, the price of copper, vested interests, &c., are we going to add to the list the trade itself, and drift down to that most exemplary and commendable of all methods of trading which may be familiarly expressed in the words, "Given away with a pound of tea?" Let me illustrate it. The vendor of transformers will advertise thus:—"To every purchaser of our celebrated transformer will be given away *absolutely free of all cost whatever* one coefficient of self-induction." I say this in all seriousness, and let those who are inclined to laugh pause a moment and ask themselves why the electric lighting business drags on so slowly. Is the Act of 1882 the sole cause? No, they will come to the conclusion that bad work, undertaken at a price which could not possibly pay, in numbers of instances has done as much as anything else to bring discredit on electric lighting enterprise.

There is no excuse why tenders should vary in amount very widely, provided the engineer will honestly estimate for that plant which the laws of economy would suggest; but, depend upon it, directly he diverges—in order to keep down his prices and make his bid attractive—from those considerations of economy which must be paramount in all engineering questions, his undertakings will most surely drift into the chasm of dismal failure which has engulfed so many good schemes in the past.—Yours, &c.,

J. M. V. MONEY-KENT.

Connaught Mansions, Victoria-street, S.W.,
19th May, 1887.

THE ELECTRIC LIGHT IN INDIA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, writing upon the subject of "Electric Light in India" in your issue of April 15th, makes some statements which are quite incorrect, and which I hope you will, in justice to me, rectify.

After enumerating several installations in this country, most of which have been working for years past, he winds up his letter by saying that "the entire work, mechanical and electrical, was done by native hands, under the superintendence of Mr. Fischer, of the Indian Electric Light Company." As a matter of fact Mr. Fischer had absolutely nothing to do with at least two of the installations, viz., the Royal Bombay Yacht Club and the Clock Tower, both of these having been erected and worked under my supervision only.

The club installation consisted of 300 Swan-Edison 100-volt lamps, distributed over the front of the club, in addition to the 300 in use every night, and were worked by means of two F 2 Victoria compound dynamos. Brush arcs only were used for lighting the Clock Tower, and the windows and clock were certainly *not* painted a light green.—Yours, &c.,

J. O. S. ELMORE, late Eastern Electric Light
May 5th. and Power Company (Limited).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a letter headed "The Electric Light in India," on p. 495 of your issue dated 15th April last. Your correspondent, after touching upon the illuminations up country, proceeds to describe what was done in Bombay on the occasion of the Jubilee. I would beg to point out certain discrepancies in the article:—

1. The Bombay Yacht Club has been lighted for years by incandescent lamps with plant purchased from a company with which Mr. Fischer had no connection.

2. The Clock Tower was lighted independently of either Mr. Fischer's plant or superintendence.

3. As regards the lighting of the Victoria Terminus, I am in a position to state that the most Mr. Fischer did was to supply the plant required at a very fair remuneration. The electric part of the work was carried out by my department, while the mechanical details were supervised by one of the company's locomotive-engineers.—Yours, &c.,

A. R. M. SIMKINS, Telegraph Superintendent.

Great Indian Peninsula Railway Company,
Bombay, 6th May, 1887.

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THE ELECTRICIAN.

SUBSCRIPTIONS.

THE ELECTRICIAN *can be had, by order, from any newsagent, in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE TELEGRAPH AND MILITARY TACTICS.

We are glad to notice that the officers of that branch of the army which is most closely associated with the application of telegraphy to military purposes are still actively encouraging its extension. Colonel HALE'S and Major BERESFORD'S papers, at the UNITED SERVICE INSTITUTION, last Friday, and the discussion which followed, are calculated to have good results sooner or later, notwithstanding the discouraging observations of Lord WOLSELEY, who presided. It is undoubtedly discouraging to hear propositions of this kind discussed, not on their merits, but on their chance, or rather their certainty, of being rejected at head-quarters. According to this high authority, if you bring a useful suggestion to the notice of the WAR OFFICE an official in one room writes a formal minute to an official in the next room, and in due time receives a formal minute in return, the upshot of which is that the matter need not be gone into any further, seeing that the Department has no funds. It would appear that unless by some happy, or unhappy, accident one arm of the service can be crippled in order to buy crutches for another, no money can ever be spared to effect the most valuable and most urgent of reforms. It is the old story; the army is starved in order that its parliamentary chiefs may not be bothered. That it is an old story is, perhaps, our one solitary consolation; for in spite of the traditional block at the War Office and the everlasting parsimony of Parliament, we have managed to pull through somehow, though of late years not always with credit. Generals and officers with firm wills of their own have got what they wanted in the long run; and it is the business of men like Colonel HALE and Major BERESFORD, who have an excellent thing to recommend, to convince their superiors that they ought to get it. Some day they are sure to have it; though not, perhaps, until the requisition is written with gunpowder or blood.

In the matter of military telegraphy, however, we are happy to learn that England is not far, if at all, behind the great nations of the Continent. It is little less than a gross scandal that communication with our most important arsenals and fortified places is still maintained by such a very unsatisfactory appliance as the A B C alone. But in respect to operations in the field our equipment is excellent, and the signallers probably the best in Europe. Both are inadequate, however, to meet a great emergency; and although we have some very superior signalling instruments, those invented by Captain CARDEW, and a first-rate light cable, there are not enough of either; and we have not yet made up our minds whether they may or may not be relied upon for tactical purposes with a fighting army. Hitherto the telegraph has not found much favour for the greater operations of war, and its comparative failure in the German army in 1870-1 was a serious blow to its further development. In the years that have intervened other nations have, however, enlarged their telegraph equipments, and have organised a telegraph corps with every cavalry regiment for the purpose of erecting wires, and maintaining the communication of advanced guards, or for destroying or tapping the enemy's wires. Germany, with characteristic pedantry, still adheres to the Morse recorder, and generally to a perfectly ideal telegraph, or none at all. The next great war will probably cure her of this fancy. England has had actual experience in several little wars, and on more than one occasion has proved the tactical advantages of its field telegraph corps. She also enjoys the advantage of being foremost in all improvements in matters relating to telegraphy; and the friendly relations between the Post Office and the army have already borne fruit in supplying the latter with not only a considerable body of highly skilled telegraphists available for the superior duties of trunk lines, but also with a still larger number of men who would efficiently perform what may be called the regimental telegraph signalling. We are not competent to enter into the technical questions raised by Colonel HALE'S paper; but in regard to the main point, we are of opinion that no country is better able than England to determine the problem whether the telegraph can be made a perfectly trustworthy adjunct to a moving army in the face of the enemy.

Unless it is trustworthy under all conditions a telegraph might of course be worse than useless, for its failure, when other means of communication have been neglected, would be disastrous. It is probably the frailty, or supposed frailty, of the system as a whole, that inspires the responsible generals with apprehension. But the construction of the cables, nowadays, and the pattern of the instruments, are such that in reality render them as safe as some other warlike appliances in quite common use. A British field telegraph can go wherever the men can go, and keep its ground so long as they can keep theirs. Over long distances it is of course liable to be cut off by the emeny, but so, too, are messengers; and a comparison of speed leaves the advantage all on the side of the telegraph, even allowing for breakages and the time occupied in repairs. In many instances the cable can be erected, or buried, or submerged where orderlies could not travel, and where, consequently, communications might be kept up when other means would fail. For operations in the field it is hard to see where doubts can arise in respect to the utility of the telegraph if properly worked. In case of accident its functions can be performed by the usual method, and the commanding officers would be no worse off than they were without a telegraph to begin with. The only doubt in

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our mind is the quality of the operators detailed for such duties. Civilians could not be trusted under fire; and this being the case a less skilful body of soldiers must of necsssity be employed. The danger is in supposing that a little knowledge will go a great way when the work is very light. Major BERESFORD it seems to us rather errs in that direction. It is true that none but highly skilled operators, mostly civilians, or semi-civilians, can deal with the traffic on a long trunk line in rear of an advancing army; but this traffic is of comparative unimportance, and is generally not as urgent as are the messages between sections of an army in battle. It may be hoped that an inferior operator would keep his head, in a double sense, under fire; but a better man would be far less likely to lose it. A case once came under our personal notice where the signaller, being an indifferent telegraphist, became utterly unable to read anything in consequence of a terrible accident which had happened near to him. All he could do was to keep on mechanically repeating his first brief message of the disaster. It may be confidently asserted that in that and any similar case on the field of battle the man will forget soonest who has least to forget.

We venture on this criticism because we rather fear that the military authorities, having the means of obtaining adequate telegraphic instruction for their men, are not as diligent as they ought to be in keeping them in good practice. This is of the utmost importance; for when the men begin young every bit of continuous practice they get is so much added to their usefulness. The confidence they will feel in themselves and inspire in others would amply repay the trouble taken with their training. Major BERESFORD relies greatly on the improved appliances for re-establishing field telegraphy in the estimation of British generals. No doubt he is right; but when the hour of trial comes the most splendid equipment will be worthless unless it is manned with expert signallers; and we doubt whether any ordinary regimental telegraphers at present can be called expert, although —and this is what we are dwelling upon—they could be made so if the proper steps were taken to keep them in regular practice. We have mentioned the A B C instrument. It is admirable for an emergency, seeing that anybody can work it. But to keep it as a permanent means of communication, as Major BERESFORD tells us it is at very many of our naval and military stations, is proof that the really useful instruments, for service in a campaign are sometimes neglected. The men employed to work these A B C's might just as well have been taught the Morse, and kept to it.

ELECTRICAL PHENOMENA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following will strengthen Mr. Neville's reply to "Leakage":—

Take an old incandescent lamp, and having suspended a pair of short wires from the platinum eyes, hold it for a few seconds between the top and bottom sides of a fast running belt. If, just after withdawal from the belt, the suspended wires be brought close to the disengaged hand, a smart shock accompanied by a spark will be experienced. This experiment cannot be performed with a new lamp, I fancy because there is no film of carbon deposited upon the interior of the bulb, and thereby no inner coating made for the miniature Leyden jar formed by holding an old lamp in the manner described, and of which the outer coating is the hand.

I have often obtained fine bright brushes of electrical discharge by holding a pin point close to the main driving belt of a works engine. Usually such discharges are quite audible, emitting a king of whizzing sound.—Yours, &c.,

F. HARMAN LEWIS.

5, Claremont-villas, Alpha-road, Millwall, May 23rd, 1887.

SUBMARINE CABLES TO THE COLONIES AND INDIA.

The paper given below was submitted by Mr. O C. D. Ross to the members of the late Conference, and contains certain views which have, perhaps, not been so much discussed as have other views. Still, we are unable to agree with Mr. Ross in his suggestions, and we may say that the 4s. tariff has been under discussion and negotiation ever since the Berlin Conference two years ago. With regard to the suggested new cables, a glance at a map giving existing cables shows that all the points referred to at which there is any trade whatever—except the Mauritius—are already supplied with cable communication. It is difficult to see why our Government alone, or in conjunction with the Colonial Governments, should be asked to provide £160,000 subsidy per annum when they can for less than half that amount get a 4s. tariff by agreement with existing lines. We are still of the opinion that of necessity the West Coast of Africa cable will be ultimately carried to the Cape, and no doubt the exigencies of business, aided by politics, will cause Madagascar and the Mauritius to be included in the cable system.—ED. *E.*

The subject of telegraphic communication between Australia and the United Kingdom was discussed at the Colonial Conference held on Wednesday, April 27, at which time the following suggestion was in the hands of Sir Henry Holland and of most of the colonial representatives. It perhaps originated the proposal of the tariff of 4s. per word.

The subject of telegraphic communication between the United Kingdom and Australia by an alternative route from that supplied by the Eastern Extension Telegraph Company is engaging the attention of the Colonial Conference, Sir H. Holland having called special attention to it in his opening speech at the Foreign Office on April 4th, on which occasion he pointed out that it is "impossible to overrate the value of our extensive submarine system, either from a political or commercial point of view." . . . . "In commercial transactions," he said, "there are few of any magnitude which do not involve the forwarding and receiving of telegraphic messages; and it is of great importance that the control of the telegraphs should be, as far as possible, in British hands, while it is of equal importance that the tariffs should be as low as it is possible to make them." To this he added that he wished to direct the attention of the Conference to, and requested the Australasian and Canadian members to favour H.M.'s Government with, their views on, a proposal to connect Canada and Australia by a cable (about 7,000 miles in length) from Vancouver's Island to some point in one of the Australasian colonies, although "a very strong case would have to be made out to justify H.M.'s Government in proposing to Parliament to provide a subsidy for maintaining such a cable in competition with the existing companies."

Now, whilst fully concurring in the great importance to Australia and New Zealand of an alternative route for the transmission of messages to and from this country and Europe at a less onerous tariff than that charged by the existing companies, we would venture to submit to the representatives of the colonies that their object would not be best attained by means of such a cable to Vancouver's Island, because in the first place the messages would have to pass from thence to Quebec, over 3,047 miles of land lines, subject to interruptions at times from accidents due to the inclemency of the seasons, and possibly at others from Indian, Fenian, or other mischievous raiders. The climate of Persia is probably less severe than that of the Rocky Mountains and Manitoba, and yet the following report was some years ago addressed to the India Office by the late Colonel Sir J. Champain, with reference to the Indo-European telegraph which runs through that country:—"During the past winter it was absolutely impossible to repair breaks on some of the sections in Persia, where wire, posts and all, were for some weeks buried under the snow." And again:—"During December the Persian lines only worked five days, and only seven days during January, the messages having to be forwarded by estafette." Again, there is a second very serious objection, which is, perhaps, equally fatal. The distance by cable from Quebec to Liverpool is 2,709 geographical miles, and the total distance from Liverpool to Sydney, *vid* Vancouver's Island, would be no less than 13,190 miles; so that if from thence the lines were continued "to India over the existing Australian land lines and through the Straits, with extensions to Aden and the Cape in one direction and to Hong Kong in the other" (as proposed by Mr. Henniker Heaton), the distance from Liverpool to India or Kong Kong would be increased to about 18,000 miles, and that to the Cape to about 22,000, which would render these extensions totally unremunerative, because they could not convey messages to Europe in competition with the much shorter routes with which that traffic is already supplied, the present charge to any part of India being only 4s. per word.

But a large traffic in messages is as essential to a cable company as passengers and goods are to a railway, and no one can question the enormous importance of adding the Indian traffic to that of Australia in any new scheme for an alternative telegraphic route, inasmuch as it would not otherwise be possible to introduce a favourable tariff. The number of messages passing over the cable, as well as the charge which must be made for their transmission, will be in proportion to the amount of commerce of the countries with which the cable communicates; and whilst the trade of Australia and New Zealand amounted last year to £119,000,000, of which one-half is with the United Kingdom, that of India, Ceylon, and the Straits Settlements amounted to £199,000,000. It may therefore be safely assumed that a cable which should combine the traffic derived

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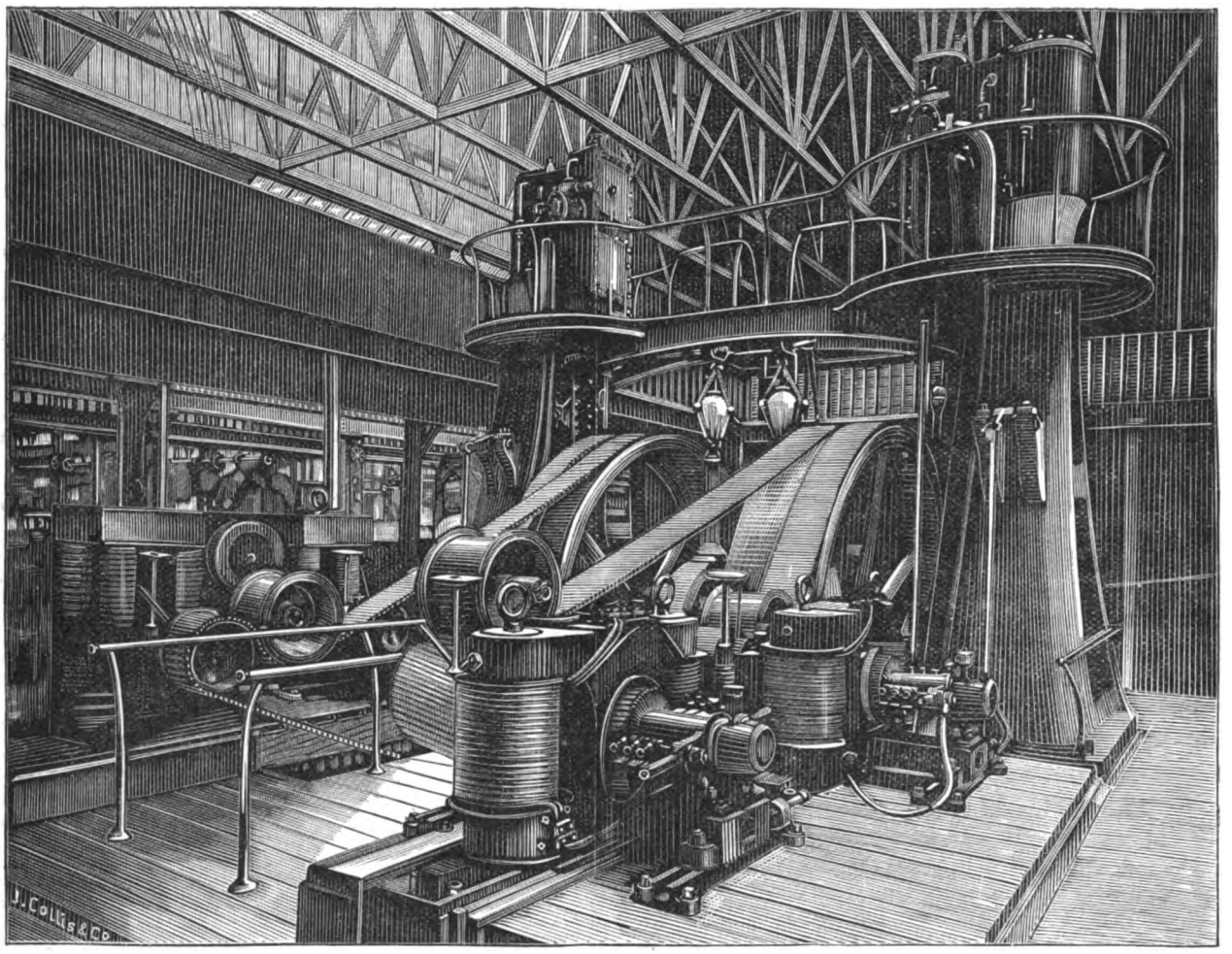
from Indian commerce with that from Australasia would permit of a far lower tariff being adopted than one which would carry only messages to or from Australia and New Zealand.

Now, it may be seen by a glance at the map that a series of cables with English stations throughout the whole distance might be laid from England to Australia *vid* the Cape, no single length of which need exceed 1,700 miles. Starting from Falmouth or the Land's End, such a cable would touch at a great many important points, viz., Gibraltar (1,050 miles), River Gambia (1,600), Sierra Leone (580), Ascension Island (1,000), St. Helena (720), the Cape (1,700), Natal (800), Mauritius (1,500), Chagos Archipelago (1,200), Ceylon (900), Singapore (1,600), and Exmouth Bay in Western Australia (1,000), from whence by the existing land lines it would connect with Melbourne (Victoria), Adelaide and Sydney, &c., and might be continued by an independent line to New Zealand (1,050 miles). With such a cable system, entirely controlled by one and the same company, a very much reduced tariff might be introduced—for at a charge per 1,000 miles of 3d. per word, the tariff to New Zealand (the most distant point) would be but 4s.; to Sydney or Melbourne, &c., 3s. 9d.; to Singapore, 3s. 3d.; to India, 3s.; and to the Cape, 1s. 8d.; against the corresponding 10s. 6d., 9s. 6d., 6s. 5d., 4s., and 8s. 11d., which are the respective prices now charged by the Eastern Telegraph Company. We need cite but one fact to show that such a tariff could not fail to be remunerative.

When the Atlantic cable was first established, our total trade with the United States (in 1865) was under £60 millions, as against the existing Indian and Australasian trade of £318 millions, but it produced during that year more than £400,000, or at the rate of, say, £1 for every £150 of trade, whereas, if we calculate the receipts from the Australasian and Indian trade at only one quarter of that proportion, or £1 for each £600 of trade, the receipts from the messages from the trade of India, the Straits, and Australasia at the above low scale of rates would amount to £530,000 per annum, and, deducting £80,000 a year for working expenses and reserve fund, there would remain a net balance of £450,000 wherewith to pay interest on the capital. This does not include the Cape trade or that of the many other stations on the African coast, which is considerable.

At £250 per mile, which since the fall in the value of copper is an ample price, the cost of laying these cables would be £3,500,000; and if, with a view to possible extensions, the capital of the cable company should be raised to £4,000,000, such earnings would provide a dividend at the rate of 11 per cent. per annum. When it is added that the Eastern Telegraph Company and the Eastern Extension Company have a combined capital of a good deal more than twice that amount—viz., £9,147,000, and that their united revenue amounted in 1886 to £1,178,000, it cannot but be admitted that our estimate is a very moderate one. It would be sufficient, however, that the Imperial or Colonial Governments should guarantee a minimum revenue of £160,000 per annum, in order that the requisite capital for laying such cables should be immediately raised without the least difficulty, and of that guarantee it is highly improbable that they would ever be called upon to disburse a single penny.

ELECTRIC LIGHTING AT THE MANCHESTER EXHIBITION.



Messrs. Mather and Platt's Vertical Engines and Dynamos for Lighting the Fine Art Section of the Royal Jubilee Exhibition, Manchester, 1887.

The portion of the Electric Lighting Department adjoining the Machinery in Motion Section has been reserved for the electrical plant for lighting the Fine Art Galleries (14 in number), which are situated on the north side of the eastern nave. Both engines and dynamos have been constructed by Messrs. Mather and Platt, of the Salford Ironworks, Manchester. The engines have been specially designed for electric lighting work, and embody several interesting and novel features. In their general arrangement and in the method of driving Messrs. Mather and Platt have specially held in view the requirements of a central station installation, or a large mill installation, where economy of floor space is usually of primary importance. When the engines are worked to their full power, and the dynamos replaced by the next standard larger size, the whole plant would be capable of supplyin current for 4,000 lamps of sixteen candle-power, while the total floor space occupied does not exceed 30ft. by 20ft. Another essential condition of electric lighting engines is a sensitive, quick-acting automatic cut-off. This is accomplished by an entirely new form of cut-off valve recently patented by Messrs. Mather and Holgate, which is described below.

The engines, which we now illustrate, are of the vertical high-pressure condensing type, with a single inverted cylinder, 20in. diameter and 30in. stroke, intended to run at 120 revolutions per minute, and to work with a boiler pressure of 100lb., and under these conditions will each indicate about 200 horse-power. The two engines are entirely independent, each having a separate fly-wheel and independent off-bearings, but they are connected together by a bridge, to give access to the cylinders and valves. The cylinders, cylinder slide, and crank-bearing pedestal are cast in one piece, with the trunk or frame, which is of a box section, closed

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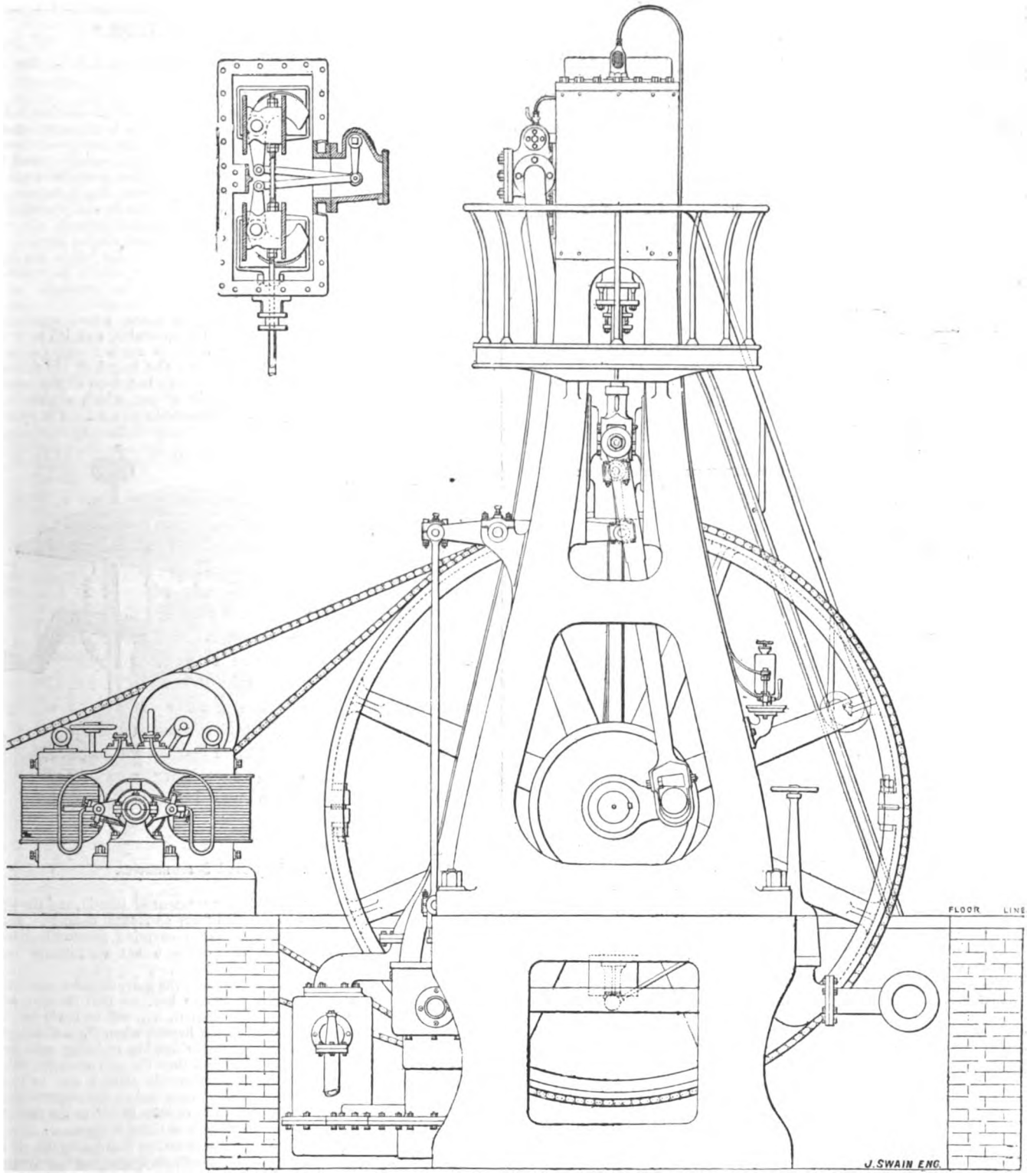
entirely back and front, but open at the sides. The form is very rigid, and looks massive and substantial in design; at the same time, as the frame casting is only ⅜in. thick, it is actually not so heavy as it appears. The cylinder is fitted with a loose liner, which forms the steam jacket. The valve box is bolted on loose, and has double slide valves so as to get straight ports from the valve box to the cylinder. In the main slide valves the ports are straight on the cylinder side, but the passages are obliquely directed within the block of the valve, so that the ports on the off side are curved, the edges being circular. The main valves are worked in the usual way, with an excentric on the crank shaft. The cut-off valves work on the back of main valves, with a reciprocating motion, also derived from an excentric on the crank shaft. These valves have curved edges corresponding to the curvature of the ports of the main valves, and are carried on pivots fixed in the slide block. The cut-off valves can thus turn about an axis at right angles to the axis of the cylinder in addition to their rectilinear reciprocating motion. The point of the stroke at which the steam is cut off depends upon the angular position of the cut-off valve, which is regulated directly by the governor through a suitable series of levers. This form of cut-off has given exceedingly good results on smaller engines. Applied to an ordinary horizontal engine, indicating 20 horse-power, it was found that when 50 per cent. of the whole load was suddenly thrown off the momentary variation in speed did not exceed 4 per cent., which was immediately reduced to 1¼ per cent., and that with the *whole* load suddenly thrown off the rise in speed was 2½ per cent. only.



Scale ¾in. = 1ft.

The piston rod and crank pin are steel, and the connecting rod best hammered scrap. At the cross-head end the connecting rod is forked, and the wear taken up by a wedge and screw; its length is three times the stroke. The crank is of steel, and balanced and covered with a cast-iron shield. It is shrunk, and keyed on to the

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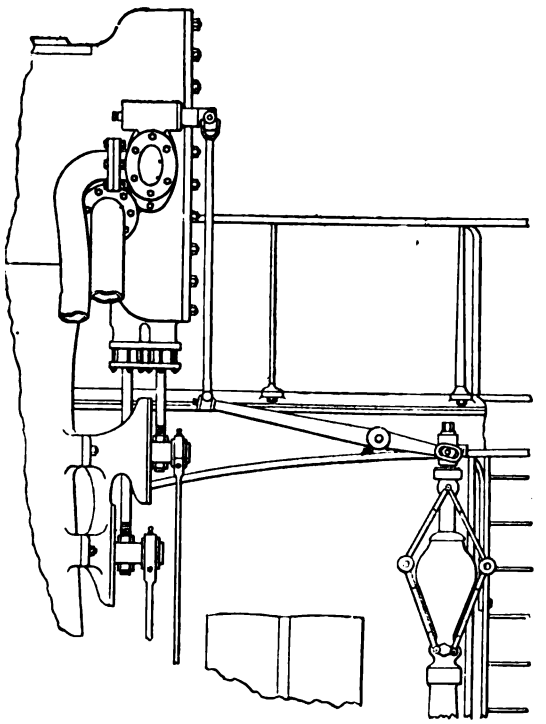
shaft; the crank pin is also shrunk in. The shaft is 8in. in diameter, bossed up to 8½in. for the fly-wheel, and at the crank end is carried in a bearing 15in. long, and at the off end in an angle pedestal 12in. long and 6½in. diameter. The main bearing is adjustable both top and bottom and at the sides by wedges and screws, so that the brasses can be fixed in any way while the engine is at work.

The fly-wheel is 12ft. diameter and 30in. wide, and is prepared for two 13in. belts. It was cast whole, split and bolted together at the rim, and held with bolts and shrunk hoops at the boss; its finished weight is 5¾ tons. All the bearings, the excentrics, crank pins, &c., are lubricated from one oil tank, to which the oil is pumped from a tank at a lower level, into which it collects from the drippers. The cylinder is lubricated by Mather and Platt's improved sight feed lubricator, requiring one plug valve only.

The air pumps and condenser are of the ordinary vertical type fixed below the floor. The pump is single acting, 12in. diameter, 15in. stroke, and is worked by a beam from the engine crosshead. Throughout, all threads on bolts are fine pitch or gas threads, and in working parts have a nut of ordinary depth, locked with a thin one, and in addition have a split cotter through the end of the bolt.

The left hand engine drives two Edison-Hopkinson dynamos, both shunt-wound for an output of 105 volts 320 amperes at a speed of 750 revolutions per minute, equivalent to 500 lamps of 16 candle-power. These machines have a commercial efficiency of 93·3 per cent., and an electrical efficiency of over 95 per cent.



Scale ¾in. = 1ft.

The improvement made in these dynamos by Dr. John Hopkinson and Messrs. Mather and Platt since the original Edison type is effectively shown by comparing the two smaller Edison-Hopkinson dynamos with the four Edison dynamos of the type which are at work close by. Although only about one-third the weight of the Edison dynamo the Edison-Hopkinson dynamos give a larger output and have a higher efficiency.

The right hand engine drives two Manchester dynamos, compound-wound, for an output of 100 volts 400 amperes, at a speed of 750 revolutions per minute, equivalent to 700 incandescent lamps of 16 candle-power.

The efficiency of the Manchester dynamo is also very high. With the full load the electrical efficiency is 94·8 per cent., and the commercial efficiency 92·8 per cent. These dynamos, as also the Edison-Hopkinson, are driven direct from the fly-wheels of the engines with link bolts. In order to increase the lap of the belt on the driving pulley of the dynamo it is bent on the slack side under a loose pulley riding on a stud carried on an arm projecting from the dynamo bed. This system of using a "jockey" pulley instead of a large belt is very effective when it is desirable to economise floor space. It was introduced by Messrs. Mather and Platt some years ago for dynamo driving, and has given good results. Careful experiments show that there is very little friction in the arrangement, and no undue wear of the belt.

The belts employed for driving the dynamo are worthy of notice, as, instead of having flat faces, as is usual with link belts, the section is double concave, so that the pins are not bent as the belt is bent over the convex surface of the pulleys. At the side of the vertical engines is a small double cylinder diagonal engine, driving a 20 horse-power Manchester dynamo. This is employed for generating the current, which is conveyed by cable to Messrs. Mather and Platt's exhibit in the Machinery in Motion Section, where a large ten-colour calico printing machine and an electrical singeing machine are driven by Manchester motors.

MODES OF MEASURING THE CO-EFFICIENTS OF SELF AND MUTUAL INDUCTION.*

By Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., Members.

(*Continued from page 41.*)

Unless the glass tube in the secohmmeter described in our last issue be rather long, either the sensibility or the range of the instrument must be limited; but a very long straight tube would make the instrument inconveniently large, and a rapidly rotating *spiral* tube would probably break from centrifugal force acting on these parts of the tube that were not on the axis of rotation. Hence, in the latest form of secohmmeter, Fig. 6, we have been led to employ a *stationary* spiral glass tube, G, with its end cemented into a stationary hollow steel conical plug, fitting mercury-tight in the collar of the rotating metal box B, with its weighted elastic sides. This arrangement simplifies the tap mechanism, seen to the left in the figure, as the tap is not now rotating; also many small improvements have been introduced into this last form; for example, at all the joints there is mercury under pressure, so that there is no tendency for air to be drawn into the apparatus at the joints, a fault which sometimes occurred with the earlier form of the apparatus, and led to irregularities in the readings from a bubble of air in the box acting as an air spring, or from air in the glass tube altering the length of the thread of mercury. The temperature adjustment in this last form of the secohmmeter is made by screwing the screw S in or out, which slightly alters the volume of the stationary portion of the mercury vessel. The fly-wheel

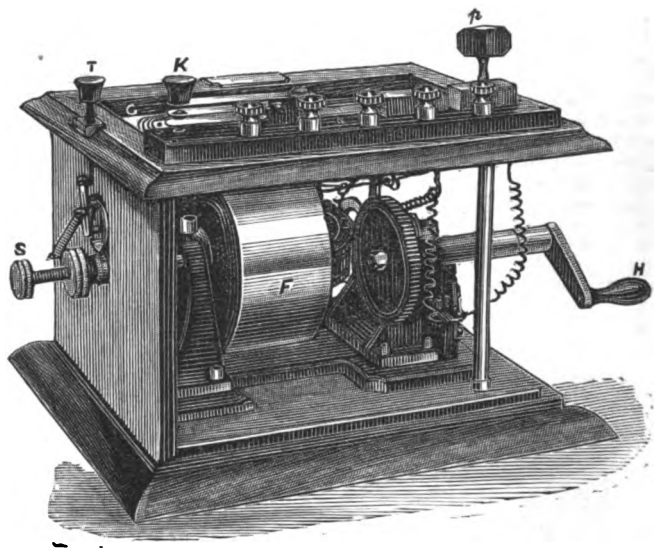


Fig. 6.—Improved Secohmmeter.

F has been made to have a much larger moment of inertia, and the box B is placed inside it, so as to be screened from accidental damage. Figs. 5 and 6 are similarly lettered, so that the description previously given of Fig. 5 refers equally well to those parts of Fig. 6 that are common to the experimental and the improved secohmmeter.

As both the wires from the battery and the galvanometer come to the secohmmeter, it is provided with a bridge key, so that the test of the ordinary resistance of the coil, electro-magnet, &c., can be made by using the same key as is used in putting on the battery when the self-induction experiment is being made. When the bridge key is being used in the ordinary way to first close the battery and then the galvanometer circuit, it is obviously necessary that the battery circuit should not be permanently broken nor the galvanometer short-circuited at the commutators of the secohmmeter, which may by chance have been left after the last experiment in a position which does one or both of these things.

Hence, when using the first form of the apparatus, Fig. 1, page 18, we were compelled to always make sure that the commutating arrangement was put in the right position when at rest before making the ordinary bridge test. Finding this, however, rather troublesome, the key in the instrument, Fig. 5, page 40, is made in the following special way:—In addition to the knob K, and the top-spring being able to be depressed, as on an ordinary bridge key, it can be moved sideways, and a cam and spring cause it to remain in one or other of two definite positions. When turned to the left, the commutators are cut out altogether, and the key acts as a simple bridge key, so that on being depressed it closes the battery circuit and then the galvanometer circuit; but when turned to the right, the commutators are

* Paper read before the Society of Telegraph-Engineers and Electricians on April 28th, 1887.

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introduced, the one into the battery circuit, the other into the galvanometer short circuit, and the key now simply enables the battery circuit to be closed now and then, or kept permanently closed when balance is being obtained during the self-induction test.

In the last form of the instrument, Fig. 6, with the stationary spiral glass tube, the knob of the key has no side motion, and the connection of the commutating arrangement with the bridge or its disconnection from the bridge is effected by an auxiliary plug key, p; but Messrs. Nalder Bros, the makers of the secohmmeter, are rather in favour of a simple means of carrying out the method, which we used with the first form of the apparatus, of placing the commutating arrangement on the right position when at rest, and using an ordinary bridge key only.

Measuring very Small Coefficients of Self-Induction.

The first form of the secohmmeter was used during the autumn of last year for the measurement of rather small coefficients of self-induction which would be very difficult to measure by any other method, such as that of a straight piece of iron wire about 4 metres long, 3 millimetres in diameter, and having a resistance of 0·1 ohm. For such experiments a metre bridge was employed, $p+q$ (Fig. 2, page 19), being in this case the resistance of 100 centimetres of uniform platinoid wire, q being the resistance of n centimetres of this wire, and r the resistance of a German silver wire having a value of about 0·1 ohm. The following are a sample of the results obtained for the coefficient of self-induction of this iron wire referred to above:—

Revs. per Minute.	n for Balance.	Value of L.
0	50·00	
1200	50·55	0·0000244 secohms
0	49 97	
1620	50·70	0·0000237 ,,
1960	50 85	0 0000252 ,,
2750	51·20	0·0000257 ,,
0	49·90	

Mutual Induction.

After the instrument had been in use for some months for the absolute measurement of coefficients of self-induction, it occurred to us that just as the self-induction of a coil, S, could be made to act as if the resistance of the coil was increased by a definite constant amount, so the mutual induction of one coil, B, on another, S, could be made to act as if the resistance of S were increased by another definite amount the measurement of which would enable the coefficient of mutual induction to be determined by a *cumulative* test. Our idea was to place the coil S in one of the arms of the bridge, and first determine its coefficient of self-induction in the way already explained; then, in addition, to place the coil B in the battery circuit, and determine the change in the coefficient of self-induction of S, which would be of course due to the mutual induction of B on S. And the following rather long mathematical investigation, which Mr. Sumpner was good enough to carry out, at our suggestion, shows that this method of experimenting, as we anticipated, leads to an extremely simple formula or the measurement of the coefficient of mutual induction.

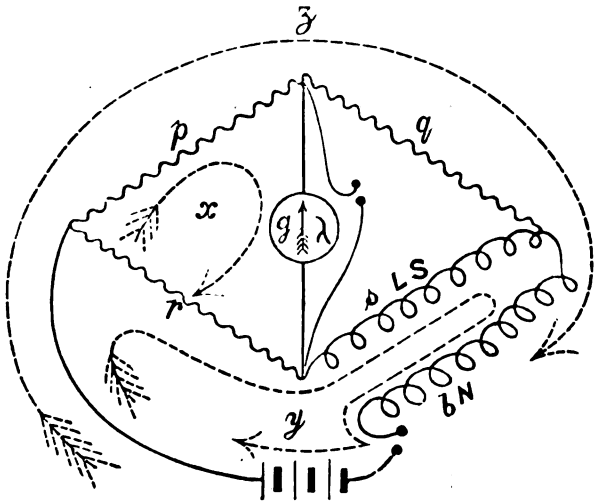

Fig. 7.

Fig. 7 differs only from Fig. 2 in that a coil of resistance, b, and coefficient of self-induction, N, has been introduced into the battery circuit, in addition to the coil of resistance, s, and coefficient of self-induction, L, which, as before, is in one arm of the bridge.

Let M be the coefficient of mutual induction of the coils on one another, then, if the battery circuit be closed and the galvanometer not short-circuited, the following equations hold true:—

$$p(x+z)+gx+\lambda\frac{dx}{dt}+r(x-y)=0 \quad . \quad . \quad . \quad . \quad (6)$$

$$p(x+z)+qz+b(y+z)+N\frac{d(y+z)}{dt}+M\frac{dy}{dt}=E \quad . \quad . \quad (7)$$

$$r(y-x)+sy+b(y+z)+(L+M)\frac{dy}{dt}+(M+N)\frac{d(y+z)}{dt}=E \quad (8)$$

Eliminating y and z from these equations we get

$$Ax+B\frac{dx}{dt}+C\frac{d^2x}{dt^2}+D\frac{d^3x}{dt^3}=Epo \quad . \quad . \quad . \quad . \quad (9)$$

where A, B, C, and D are functions of the resistances and coefficients of self and mutual induction, such that

$$A+Bu+Cu^2+Du^3$$

is identically equal to the determinant

$$\begin{vmatrix} (p+g+r+\lambda u) & p & -r \\ p & (p+q+b+Nu) & b+(M+N)u \\ -r & \{b+(M+N)u\} & \{b+r+s+(L+N+2M)u\} \end{vmatrix} \quad . \quad (10)$$

and where σ is the apparent increase of the resistance of the coil S, as determined by the change necessary to be made to obtain balance when the secohmmeter is rotated at a certain speed, balance having been previously obtained when the secohmmeter was at rest; or, in other words,

$$p(s+\sigma)=qr$$

when the secohmmeter is being rotated at this certain speed.

Then, in accordance with the plan adopted in the solution of the original problem (see page 19), we may divide the effect on the galvanometer into two portions, the one produced from the closing of the battery circuit to the short circuiting of the galvanometer, occupying a time T, the other taking place during the short-circuiting of the galvanometer, occupying a time T′ − T. If Q_1 be the quantity of electricity that passes through the galvanometer in the first interval, Q_1 may be obtained from the following equation obtained from integrating (9) from t equal nought to t equal T:—

$$AQ_1+B(x_T-x_0)+C\left\{\frac{dx}{dt_T}-\frac{dx}{dt_0}\right\}+D\left\{\frac{d^2x}{dt^2_T}-\frac{d^2x}{dt_0^2}\right\}=Epo\,T \quad (11)$$

where the suffix T or 0 after any expression decides the value to be given to t in the expression.

Following a similar train of reasoning to that employed in the original investigation, we find from equations (6), (7), and (8) that

$$x_0=o, \quad y_0=o, \quad z_0=o,$$

$$\frac{dx}{dt_0}=o \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

$$N\frac{dz}{dt_0}+(M+N)\frac{dy}{dt_0}=E,$$

$$(M+N)\frac{dz}{dt_0}+(L+N+2M)\frac{dy}{dt_0}=E,$$

and by differentiating (6) and using (12) we have

$$p\frac{dz}{dt_0}+\lambda\frac{d^2x}{dt_0^2}-r\frac{dy}{dt_0}=o.$$

From these we can deduce that

$$-\lambda\begin{vmatrix} N & M+N \\ M+N & L+N+2M \end{vmatrix}\frac{d^2x}{dt_0^2}=\{p(M+N)+rM\}E.$$

This, by (10), is equivalent to

$$-D\frac{d^2x}{dt_0^2}=\{p(M+N)+rM\}E.$$

We have next to consider the values of the expressions when t equals T, which time we assume to be long enough for the currents to become steady, therefore

$$x_T=\frac{Epo}{A}, \quad \frac{dx}{dt_T}=0, \quad \text{and} \quad \frac{d^2x}{dt_T^2}=0,$$

so that, substituting the values of the various expressions in (11), we have

$$AQ_1+\frac{B}{A}Epo+(L+\frac{p+r}{p}M)Ep=Epo\,T \quad . \quad . \quad (13)$$

At the time T the galvanometer is short-circuited and the current in the galvanometer dies away, following the law

$$gx+\lambda\frac{dx}{dt}=0;$$

so that if Q_2 is the quantity that passes through the galvanometer from t equals T to t equals T′, T′ − T being the time during which the galvanometer is short-circuited,

$$gQ_2+\lambda(x_{T'}-x_T)=0;$$

and

$$x_T=\frac{Epo}{A},$$

also

$$x_{T'}=0,$$

since, by hypothesis, T′ − T is long enough for the current to die away in the galvanometer;

$$\therefore Q_2=\frac{Epo}{A}\cdot\frac{\lambda}{g}$$

And since for no deflection of the galvanometer needle we must have

$$Q_1+Q_2=0,$$

it follows that

$$AQ_1=-Epo\frac{\lambda}{g},$$

and equation (13) reduces itself simply to

$$L+\frac{p+r}{p}M=\sigma\left(T+\frac{\lambda}{g}-\frac{B}{A}\right). \quad . \quad . \quad . \quad . \quad (14)$$

an equation only differing from equation (4), page 20, the result obtained in the original investigation, by the addition of the term

$$\frac{p+r}{p}M,$$

depending on the coefficient of mutual induction. And since, as will be shown later on, $\frac{\lambda}{g}-\frac{B}{A}$ is small compared with T, just as it was in the

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original investigation, we have approximately

$$L+\frac{p+r}{p}M=\sigma T \text{ secohms},$$

which, as before, may be written as

$$L+\frac{p+r}{p}M=\frac{60\,l}{N}\sigma \text{ secohms} \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

where l is the lead in the secohmmeter, and N the number of revolutions per minute which cause an apparent increase of resistance σ ohms of the coil S.

To make, therefore, the complete test for determining the coefficient of self-induction, L, of the coil S, and the coefficient of mutual induction, M, between it and any other coil, we first exclude the other coil from the battery circuit, as shown in Fig. 2, page 19, and determine L in the manner already described. We next include the other coil in the battery circuit, as shown in Fig. 7, and repeat the experiment with this secohmmeter, then

$$M=\frac{p}{p+r}\left(\frac{60\,l}{N}\sigma-L\right),$$

or, if N_1 and σ_1 are the speeds and apparent increase of resistance in a first experiment, and N_2 and σ_2 in a second, we have

$$L=60\,l\,\frac{\sigma_1}{N_1}$$

$$M=\frac{p}{p+r}60\,l\left(\frac{\sigma_2}{N_1}-\frac{\sigma_1}{N_1}\right) \quad . \quad . \quad . \quad . \quad . \quad (16)$$

We have stated above that $\frac{\lambda}{g}-\frac{B}{A}$ is generally small compared with T, and to ascertain the value of $\frac{B}{A}$ in (14), in order to investigate this, we may write

$$\frac{B}{A}=\frac{B_1}{A}\lambda+\frac{B_2}{A}L+\frac{B_3}{A}M+\frac{B_4}{A}N;$$

then it is easy to show that

$\frac{A}{B_1}=g+$resistance of network between the extremities of g, supposing g removed,

$\frac{A}{B_2}=s+$resistance of network between the extremities of s, supposing s removed,

$\frac{A}{B_4}=b+$resistance of network between the extremeties of b, supposing b removed,

$\frac{A}{B_3}=\frac{1}{2}$ the ratio of the value of an E.M.F. inserted in the branch s, to the steady current set up in the battery branch, b, by this E.M.F. in s.

Writing r_g, r_s, r_b for the three resistances represented by $\frac{A}{B_1}$, $\frac{A}{B_2}$, and $\frac{A}{B_4}$ respectively, and r_{bs} for the ratio of the E.M.F. in s to the current produced by it in b, equation (14) becomes

$$L+\frac{p+r}{p}M=\sigma\left(T+\frac{\lambda}{g}-\frac{\lambda}{r_g}-\frac{L}{r_s}-\frac{N}{r_b}-\frac{2M}{r_{bs}}\right) \quad . \quad (17)$$

If g is as large or larger than the resistances of any one of the arms of the bridge, $\frac{\lambda}{g}-\frac{\lambda}{r_g}$ will be very small. $\frac{\sigma}{r_s}$ is generally small compared with unity, and therefore $\frac{\sigma}{r_s}L$ can be neglected in comparison with L, so can $\frac{2\sigma}{r_{bs}}M$ in comparison with $\frac{p+r}{p}M$.

There remains the term $\frac{\sigma}{r_b}N$. If N be very large, then will b also be very large, and as r_b is much larger than b, while σ will be much less than b if b be large, it follows that the term $\frac{\sigma}{r_b}N$ can also generally be neglected; hence the approximate formula (15) will usually be accurate enough for practical purposes. And the value of any one of the last three fractions in the bracket in (17) can be made as small as we like, by adding resistance without self-induction to s or to b, a precaution that it is desirable to adopt if it be feared that any one of these three fractions is not negligible in comparison with T.

(To be continued.)

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis :—

ON THE MIGRATION OF IONS AND AN EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITY.

BY DR. OLIVER LODGE.

(Continued from page 526, Vol. XVIII.)

The following abbreviated excerpts from Laboratory Note-books will sufficiently illustrate the results so far attained.

Specific Gravity Data.—11·73 grammes of crystallised baric chloride added to 88·27 grammes of water give a solution of sp. gr. 1·095, containing about 10 per cent. of the salt itself. One-thirtieth of its bulk of water added reduces it to 1·093. 22·68 grammes of crystallised sodic sulphate added to 77·32 grammes of water give a solution of specific gravity 1·093, likewise containing about 10 per cent. of the salt itself. 19·98 grammes of hydrochloric acid added to 80·02 of water make sp. gr. 1·098, and is a 25 per cent. solution. This also was reduced to 1·093.

Experiment made of inverting a test tube containing one of these liquors into a pneumatic trough containing another. In each case pretty rapid mixture resulted.

The hydrochloric acid solution was then diluted with an equal volume of water, making its sp. gr. 1·030. A test tube was filled with this and inverted over the baric chloride solution. There was no visible mixture; the place where the two liquids meet remained quite sharp.

October 30, 1885.—A tube of uniform cross section and ·41 centimetre internal diameter was taken and bent as shown in Fig. 2. Its total length was 84·2 centimetres. This tube was marked No. I.

It was filled with hydrochloric acid solution, of specific gravity 1·030, slightly tinged with litmus.

Two vessels containing the 1·093 solution of Na_2SO_4 and $BaCl_2$ respectively were arranged with vertical sticks of electric light carbon as electrodes, and their levels as carefully adjusted as possible. The final adjustment was performed by a short siphon tube with a pinch-cock in the middle, and full of hydrochloric acid of sp. gr. 1·093 (see Fig. 3). The experimental tube No. I. was then introduced very carefully at xiv. hrs. 58 min. At xv. hrs. 2 min. the pinch-cock of the levelling tube was closed, and the current started, flowing from $BaCl_2$ vessel to Na_2SO_4 vessel. Current strength ·01 ampere.

October 31.—Noon: ring beginning to form.

22 centims. from Na_2SO_4 end, and
62·2 ,, ,, $BaCl_2$ end.

November 2, 1885.—Another similar experiment with same tube. Levelling tube started at xi. hrs. 49 min. Experimental tube put in xi. hrs. 55 min. Levelling tube closed at xii. hrs. 2 min., and current started of strength ·01 ampere.

By November 3, at ix. hrs. 47 min., ring formed; and at xiv. hrs. the current was stopped. Strength, ·007 ampere.

Solutions then tested and found all right; apparently a satisfactory experiment.

Distance of ring
from Na_2SO_4 end 24·6;
,, $BaCl_2$,, 59·6.

November 3.—Another experiment started with the same tube; fresh liquids still with density 1·093 for $BaCl_2$ and Na_2SO_4, the HCl (coloured with litmus) of density 1·030. Levelling tube put in at xiv. hrs. 30 min.; experimental tube at xiv. hrs. 34 min. Levelling tube closed and current started at xiv. hrs. 36 min. Strength of current ·009.

On November 4 at x. o'clock the ring was formed.

Distance from Na_2SO_4 end 31·8 centims.
,, $BaCl_2$,, 52·4 ,,

November 4.—Similar experiment, except that the tube is filled with an uncoloured solution of HCl of ordinary testing strength—that is, one centigramme molecule in 5 cc. Average current strength, ·009.

Distance of ring from Na_2SO_4 end 16·8 centims.
,, ,, $BaCl_2$,, 67·6 ,,

November 6.—Another experiment with the ·01 HCl is 5 cc. Current strength, ·009.

Distance of ring from Na_2SO_4 end 16·4;
,, ,, $BaCl_2$,, 68·0.

November 7.—A blank experiment arranged purposely with no current. Tube put in and levelling tube closed at xiii. hrs. 35 min.

By November 16 *there was no ring formed and no deposit anywhere in the tube.*

November 24.—Two other similar tubes prepared, each of the same internal diameter—·41 centims.—but of lengths. No. II. 87 centims., No. III. 88·4 centims. The three tubes were then filled with the HCl solution (·01 in 5 cc) and arranged with three pairs of vessels in multiple arc. The result was that, while the precipitate occurred in tube I. in about its usual position, in tubes II. and III. it occurred quite at the end of the tube where it dipped into the Na_2SO_4 vessel, and accordingly most of it fell out of the tube.

December 1.—Another experiment started; tubes I. and II. as before, but a layer of paraffin over the vessels of tube III., and a siphon levelling tube full of paraffin dipping into it and left open, as shown in Fig. 4. The current strength decreased steadily from ·01 to ·005.

In tube II. the chief precipitate occurred again close to the Na_2SO_4 end.
In tube I. the distances were 16·5 centims. from Na_2SO_4 end.
67·8 ,, Ba_2Cl end.
In tube III. they were 20·2 ,, Na_2SO_4 end
68·3 ,, Ba_2Cl end

Precipitates appeared on Dec. 3.

December 3.—Paraffin levelling tubes now provided for both tubes II. and III. The ring formed well in all three now, and quite blocked the tube. The distances were—

In tube I.	15 centims.	from	Na_2SO_4 end.
	69	,,	$BaCl_2$.
In tube II.	21	,,	Na_2SO_4 end.
	66·4	,,	$BaCl_2$ end.
In tube III.	21·5	,,	Na_2SO_4 end.
	66·7	,,	$BaCl_2$.

Current strength in each tube about ·01 ampere.

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December 5.—Same experiment repeated with 22 cells, tube I. being the only one without paraffin. The distances were—

	I.	II.	III.
From Na_2So_4 end	16·1	22·2	22·2
From $BaCl_2$ end	67·6	64·8	66·1

Current strength about ·015

December 5.—The same experiment repeated, but with only 3 cells. By December 9 a ring had formed in II. and III., but not in I.

Distances of ring—

In tube II. { 25·9 from Na_2SO_4 end. / 60·9 from $BaCl_2$ end.

In tube III. { 27·1 from Na_2SO_4 end. / 60·9 from $BaCl_2$ end.

Current strength in each tube about ·002 ampere.

Experiments with tubes of different bore.

Two fresh tubes were prepared, Nos. IV. and V., of about the same length, but smaller in bore than the first three, No. IV. being about ·3 centim. diameter and No. V. about ·22.

(For more accurate gauging of all the tubes see below.)

December 9.—Two tubes, Nos. II. and V. arranged in series; two other tubes, Nos. III. and IV., also arranged in series, and the current from 16 secondary cells allowed to divide between the two pairs, starting at 4 p.m. on December 9.

Current strength in tubes III. and IV. decreasing from ·0075 to ·0035; in tubes II. and V. from ·005 to ·0012.

By December 11, 10 A.M., a ring was almost completely formed in tube IV., fairly so in V., an indication in III., and nothing in II. By December 12 a ring formed in tube III., and by December 14 it was beginning also in tube II.

December 14 the state of the tubes was sketched thus :—

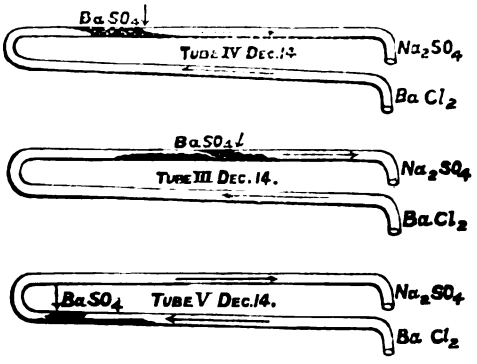

FIG. 5.

On the 15th the state of tube II. was this :—

FIG. 6[1]

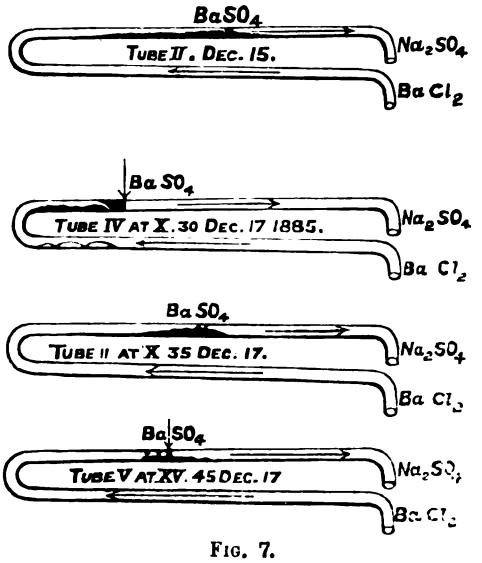

FIG. 7.

An arrow marks the place of first appearance of the ring.

The distances are as follows :—

	II.	III.	IV.	V.
Distance from Na_2SO_4 end	19·0	17·5	30·5	45·8
,, $BaCl_2$ end	66·7	69·5	54·7	40·7

December 15. 7 *p.m.*—Vessels same as in last experiment, but tubes arranged II. and IV. in series, one pair, and III. and V. in series the other pair.

Current strength in II. and IV. from ·0095 to ·0044; and in III. and V. from ·0062 to ·0022.

By December 16, 4 P.M., deposit showing itself in tube IV.

December 17, 10 A.M., ring formed in tube IV., and almost complete in II. An indication in V. By 3 P.M. the ring in V. was complete, and a slight deposit in tube III.

On December 20 ring complete in III., and current stopped.

Distances of ring when first formed—

in tube	II.	III.	IV.	V.
from Na_2SO_4 end	21·5	17·1	28·6	24·3
,, $BaCl_2$ end	64·5	69·8	56·4	62·2

Gauging of the tubes.

January 6, 1886.—Determined bore of tube by filling them with mercury at 12° C.

——	I.	II.	III.	IV.	V.
Length in centims.	82·5	85·7	87·3	85·4	86·3
Weight of mercury filling tube, in grammes	157·0	161·5	157·92	113·4	56·65
Calculated volume	11 6	2 0	11·7	8·4	4·2
Sectional area	·14	·14	·134	·0983	·0487
Diameter of bore	·423	·423	·404	·355	·25

January 7.—Experiment with all four tubes in multiple are, two of them dipping into the same pair of vessels; the solutions of Ba_2Cl_2 and Na_2SO_4, weaker than before, viz., sp. gr. 1·050, because in the cold weather the sulphate of soda was apt to crystallise out of the old solutions. Current started at 5 P.M., 20 cells. By January 9, 9 A.M., rings were formed in tubes II., III., and IV. No ring in V., but some air-bubbles had collected in it, and apparently stopped its current. The rings in II. and IV. were beautifully sharp.

	II.	III.	IV.
Distance of ring from Na_2SO_4 end	17·0	6·5	16·9
	68·7	80·8	68·5

January 9.—Another similar experiment, but with 15 cells. By the morning of January 11 rings were formed in 3 tubes, and one was forming in tube V.

	II.	III.	IV.	V.
Distance from Na_2SO_4 end	26·5	10·4	21·0	33·7
,, $BaCl_2$ end	59·2	76·9	64·4	52·6

January 22.—A precisely similar experiment, except that 20 cells were applied. By January 23 (evening) rings were forming in three of the tubes, but there was an air bubble again in V.

	II.	III.	IV.
Distance of ring from Na_2SO_4 end	34·3	22·3	24·4
,, ,, $BaCl_2$ end	51·4	65·0	61·0

February 1.—Similar experiment.

	II.	III.	IV.	V.
Distance from Na_2SO_4 end	38·2	30·6	26·2	23·1
,, ,, $BaCl_2$ end	47·5	56·7	59·2	63·2

So far the data are not satisfactory. There is a decided consensus in favour of the more rapid travelling of Ba than of SO_4, but no estimate of the ratio of the velocities can be relied on. The average makes Ba travel 3·2 times as fast as SO_4.

Experiments on jelly-filled tubes.

Four new tubes were made of dimensions and numbers here specified :—

Number	VI.	VII.	VIII.	IX.	
Length	86·6	88·3	84·8	103·8	centims.
Diameter	·327	·460	·476	·825	,,

A gelatine solution was made by dissolving 20 grammes of gelatine in 150 cc. of dilute acetic acid of ordinary testing strength, viz., 1 centigramme molecule per 5 cc., the tubes filled and allowed to go solid. The tubes were arranged in multiple arc with a galvanometer able to be switched at pleasure into the circuit of each. The solutions in the vessels were $BaCl_2$ and Na_2SO_4, as before.

February 13.—The E.M.F. of 24 cells was applied to these four new tubes at noon, and readings of the current (which was very weak) taken at intervals.

It was found that something in travelling from the anode vessel (presumably the Ba) rendered the jelly turbid, and that the turbidity, being sharply defined, served as an indication of the distance to which this ion had reached. Marks were accordingly made on the tube to fix its position at different times, the distances of these marks from the end of the tube being afterwards measured. After a time the SO_4, travelling from the other end, met the Ba and precipitated a sharp ring of $BaSO_4$, whose position was noted. The current was not stopped, however; it was left on to see at what rate the precipitation advanced, and whether it advanced in both directions or in only one. In the free liquid HCl tubes it had seemed only to advance in the direction opposed to the current, viz., towards the $BaCl_2$ vessel. It was now observed in these jelly tubes to widen out both ways, but faster towards the $BaCl_2$ vessel than towards the Na_2SO_4.

It was specially noticeable that in these jelly tubes the disc of $BaSO_4$, indicating the meeting of the ions, was formed near the middle of the tube, instead of much nearer the Na_2SO_4 end, as it had done in free liquid. Thus while Ba travelled 41·1 cm. to the meeting-place, SO_4

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travelled 45·5, in tube No. VI. In the tube No IX. Ba travels 47 8, while SO_4 travels 56·6, and so on ; see following table.

SUMMARY OF EXPERIMENTS ON TRAVELLING OF BA THROUGH FOUR JELLY TUBES.

Date.		Tube VI.		Tube VII.		Tube VIII.		Tube IX.	
Day.	Hr. min.	Distance travelled by Ba	Current milliamperes	Distance travelled by Ba	Current milliamperes	Distance travelled by Ba	Current milliamperes	Distance travelled by Ba	Current milliamperes
Feb. 13	XII 0	started	·12	started	·18	started	·22	started	·54
,, 14	XIV 0	—	·12	—	·21	—	·25	—	·56
,, 15	XII 3	6·9	·12	6·5	·24	7·1	·28	5·9	·76
,, 15	XVI 15	7 88	·14	7·41	·32	8·1	·39	6·7	·83
,, 15	XX 15	8 75	·12	8·25	·21	8·95	·25	7·3	·61
,, 16	X 10	11·12	·12	10 12	·21	11·33	·25	8·92	·61
,, 16	XIX 10	12·75	·14	12·95	·24	12·95	·28	10·2	·64
,, 17	XI 10	15·45	·11	14·55	·21	15 65	·23	12 1	·46
,, 18	X 10	19·15	·16	18 02	·26	19·32	·30	14 8	·75
,, 18	XVIII 10	21·08	·17	19 9	·26	21 25	·33	16·12	·82
,, 19	X 10	23·98	·10	22 7	·17	24 2	·21	18·3	·49
,, 19	XXI 28	25 6	·09	24·25	·16	25·93	·17	19·5	
,, 20	X 10	27 2	·09	25·85	·16	27·6	·20	20 8	—
,, 20	XX 15	—	·16	27·45	·20	29·32	·23	22 0	—
,, 21	IX 45	30·55	·11	29 2	·18	31·2	·20	23·45	—
,, 22	X 15	33·68	·12	32·55	·18	34 5	·24	25 8	—
,, 23	X 10	37·05	·10	35 72	·16	33·15	·18	28 45	—
,, 24	X 10	39·72	·09	38·5	·16	40·6	·18	30 5	—
,, 25	X 10	41·1	·11	40·85	·15	41·22	·18	32·6	—
		$Ba SO_4$ forming	disc			$Ba SO_4$ formed	disc		
				$Ba SO_4$ forming	disc				
,, 25	XXI 15	—	·09	41 3	·14	—	·16	33·7	—
,, 26	X 10	41·4	·09	—	·15	41·5	·17	34·8	—
,, 27	XII 12	—	·08	—	·17	—	·18	37·5	—
				current	stop	ped			
—	—	—	—	—	—	{42 92 / 35·4}	·13	40·9	—
*March 4	X 10	{42 65 / 36 2}	·07	—	—	—	·15	46·5	—
		current		stop	ped				
,, 4	XXIII 57	—	—	—	—	{43 16 / 34 6}	·17	47·32	—
								$Ba SO_4$ just forming.	disc
,, 5	X 10	—	—	—	—	— mms. wide	·13	Disc current	2 stopped

* The 3 pairs of bracketed numbers about this date relate to the two ends of the plug of precipitated $BaSO_4$, and show the rate at which this plug grew in thickness.

(To be continued.)

FIFTY YEARS' PROGRESS IN TELEGRAPHY.*

By W. H. PREECE, F.R.S., Vice-President of the Society.

(Concluded from page 43.)

SNOWSTORMS.

We have been subject, at long intervals of ten years, to serious and destructive snowstorms, which have seriously damaged our overground wires. The wires constructed and maintained by the Post Office did not suffer very seriously, but those maintained along the railways out of London, and erected by the Telephone Company overhead, were severely handled by the elements. In fact, in London, many unrepaired telephone wires are still seen dangling over the housetops. No accident to person has been recorded, but the very serious interruption to communication has raised earnest attention to the necessity of putting more wires underground. It has always been the practice of the Post Office to do this in London and large cities, but not only the excessive cost, but the diminished speed of working, has hitherto prevented its being done to any large extent in the country. The Postmaster General has now under his consideration a scheme for doing this more generally, and there is nothing whatever to prevent this being done by the telephone companies. In fact, in many cases, telephones work better underground than overhead. The laws that govern the transmission of speech are now thoroughly known, and the fancied difficulties in using underground wires have vanished into thin air.

In London alone we have 255 miles of pipes, containing 10,212 miles of wire. In fact, all our great trunk lines are out of danger of stoppage from storms. We have 868 miles of open wire included within the metropolitan area, but these are chiefly in the suburbs, and include long outlying sections, used either for police or fire brigade wires, or for private persons.

There are 213 offices in London now served wholly by buried wires. It will be seen, therefore, that the Post Office has been fully alive to the drawbacks attending the existence of overhead lines in crowded centres. It is steadily pursuing the same policy, and although some open wires must exist if telegraphs are to exist at all in certain localities, still the overhead proportion, as compared with the underground, steadily diminishes.

* Paper read before the Society of Arts, on Wednesday, May 18.

Comparative Return, showing the Mileage of Line and Wire in the United Kingdom.

Year.	Overhead.		Underground.	
	Line.	Wire.	Line.	Wire.
	Miles.	Miles.	Miles.	Miles.
1877	23,766¼	101,627¼	394¾	8,013¾
1878	24,438¾	102,074	445¾	9,023
1882	25,001½	111,811¾	478¼	10,993¼
1886	26,425	150,590	677¼	19,605

To provide a scheme extending throughout the kingdom to connect only the more important towns, and uniting those towns by less than half the existing number of overhead wires, would cost something like £2,500,000, and in these days of attenuated exchequers such an outlay is very serious to incur, although it may effectually guard against stoppages ranging from three days to three weeks, once in ten years or so.

TELEPHONES.

In 1877, a most striking departure in telegraphy was made by Prof. Graham Bell in America, who showed that it was possible to reproduce for commercial purposes the human voice at great distances. The telephone sprang into existence almost perfect in its action, and with the improvement immediately afterwards introduced by Mr. Edison and Prof Hughes, it has leapt into existence with giant bounds. In America there were on December 31, 1886, 353,518 telephone receivers and microphone transmitters in use and under rental. The total number of subscribers to exchanges is 147,068. In Europe the number is very great. The number of exchanges in England is 184 ; there are 19,784 subscribers, but there are 101,000 telephones in use as royalty-paid receivers and transmitters.

Stockholm has shown a remarkable development. With a population of 210,000—about the size of Edinburgh—there are over 5,000 subscribers to the exchange, while in Edinburgh there are only 372.

PNEUMATIC TELEGRAPHS.

The Electric Telegraph Company introduced, in 1854, a pneumatic tube of lead protected in iron pipes, between their central station in Lothbury and the Stock Exchange, by which the messages themselves, in small leather carriers, were drawn through by a vacuum. The system proved so economical and rapid that it was extended in the City of London, Glasgow, Liverpool, and in Manchester.

At the transfer there were altogether 2 miles 1,625 yards of pipes laid down, but now there are in :—

London	32	miles,	1,209	yards.
Birmingham	0	,,	917	,,
Liverpool	5	,,	1,593	,,
Newcastle	0	,,	1,204	,,
Glasgow	1	,,	768	,,
Dublin	1	,,	1,013	,,
Manchester	2	,,	233	,,
Total	44	miles,	1,737	yards.

The longest tube is that between the central station, General Post Office, and the House of Commons (3,859 yards), through which 700 messages are sometimes sent, each carrier taking about six minutes per journey, but intermediate signallers being employed, carriers can be despatched every two minutes. In most cases there are two tubes, one for sending and the other for receiving—through one the messages are blown, through the other they are sucked—the engines and pumps being in all cases in the central station. At the time of the transfer the engine power employed was as follows :—

	Engine.	h.-p.
London Telegraph Station	1	20
Birmingham	1	6
Liverpool	1	8
Manchester	1	10
Glasgow...	1	6
Total nominal horse-power.....		50

The engine power employed at present is as follows :—

London :—St. Martin's-le-Grand—Condensing engines. (3 are working and 1 spare)	4	each	50
Liverpool—Condensing engines. (2 are working and 1 spare)	3	,,	30
Manchester—(1 of which is working and 1 spare)	2	,,	10
Birmingham	1	,,	6
Glasgow	1	,,	20
Newcastle-on-Tyne.....	1	,,	8
Dublin—(1 of which is working and 1 spare).....	2	,,	10
	14	...	134

This gives a total of 14 engines, and a total of 354 nominal horse-power for working the 112 pneumatic tubes now in use.

CABLES.

The exclusion of private enterprise from telegraphic undertaking in these islands does not apply to our colonies and to the ocean. The growth of

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submarine telegraphy has been enormous. We read in our newspaper every morning the previous day's doings in every quarter of the world. *The Times* of May 16 had two and a-half columns from Philadelphia, one and a-half column from India, a despatch from Natal, another from Melbourne, and news from every capital in Europe.

In 1851 two or three far-seeing individuals, prominent among whom was our own vice-president, Mr. T. Crampton, risked their capital in laying a cable between Dover and Calais. Now there are 112,673 miles of submarine cable resting on the bottom of the ocean, which has absorbed a capital of £37,000,000. Appendix IV. gives a list of them.

No less than nine cables cross the Atlantic. All our important colonies are in connection with London—the heart of the world. Laying and repairing has become a simple and a certain matter in any depth and in every sea. A whole fleet of ships—over thirty—are maintained for the purpose. Submarine telegraphy has become a solid property—the main result of British skill or British enterprise—unaided by Government support. The apparatus used is principally Sir William Thomson's recorder.

Railways.

The monopoly which the Postmaster-General possesses regarding telegraphy only applies to message-carrying for profit—it does not apply to those numerous wires that are required for the protection of life on railways. Each of our large railway companies has a distinct telegraph system of its own, employing a very large staff, and used for the purpose of regulating its own traffic. There are about 80 000 miles of wire erected for the purpose, and probably 20,000 various kinds of instruments in use. The apparatus used for telegraphy is invariably the needle, though generally on the wires connecting the Post Office sounders are employed. The apparatus used for block working is very various. Every great railway out of London has a different system. The survival of the fittest has not yet asserted itself. But they all work well, and without electric signalling the working of our railway system would be absolutely impossible.

Finance.

The financial position of the telegraph business is sound. The amount of capital debited against telegraphs is £10,140,000 ; of this, £7,000,000 was the purchase money, the rest has been expended in extensions and in furthering the business. If the trust which the Post Office undertook on behalf of the public were handed back to the care of private enterprise, we should hand over a going business drawing a gross revenue of nearly £2,000,000 per annum, and assets which may be estimated at £4,000,000. If financiers were willing to pay several millions for a single brewing business in Dublin, what would they pay for a grand Imperial monopoly, serving every town in the United Kingdom, and of which every person in these islands is a customer?

It is very much the fashion to decry the terms of purchase. Doubtless, the terms paid were very high, and the Post Office authorities who negotiated the purchase were unnecessarily hurried, and perhaps overmatched by the railway companies, for they had to pay twice over for certain privileges. Even Mr. Fawcett proposed to wipe out as wasted capital the excess paid for telegraphs, and to call it a bad debt. As the bargain stands the public have not been losers. A Government department cannot compete in economy with an ordinary commercial firm subject to competition; nevertheless, the business done pays a dividend on the capital expended. The balance of profit for the year ending 31st March, 1886, if our accounts were made out on commercial principles, was £160,000.

It is amusing, after this length of time, to read the arguments that were adduced against the absorption of the telegraphs by the State. Every reason has been proved wrong, every prophesy has remained unfulfilled. I can say this with a good grace, for I was one of the prophets.

The advantages of a State-controlled telegraph system have been amply fulfilled. There has been established a cheaper, more widely extended, and more expeditious system of telegraphy; the wires have been erected to districts that private companies could not reach; the cost of telegrams has been reduced, not only in their transmission but in their delivery; the number of offices opened has been trebled; a provincial and an evening press has been virtually created. Adam Smith said that the Post Office was the only kind of business that Government had always managed with success. We can now add telegraphy.

Appendix I.

Statement of number of Telegraph Offices open at the end of each year since the Transfer :—

	Post Offices.	Railway Stations.	Totals.
At the Transfer (viz. 5th Feb., 1870)	1,058	1,874	2,932
On the 31st March, 1871	2,171	1,903	4,074
,, ,, 1872	3,266	1,886	5,152
,, ,, 1873	3 579	1,879	5,458
,, ,, 1874	3,671	1,879	5,550
,, ,, 1875	3,706	1,879	5,585
,, ,, 1876	3,736	1,866	5,602
,, ,, 1877	3,734	1,636	5,370
,, ,, 1878	3,756	1,555	5,311
,, ,, 1879	3,853	1,401	5,254
,, ,, 1880	3,924	1,407	5,331
,, ,, 1881	4,015	1,423	5,438
,, ,, 1882	4,146	1,449	5 595
,, ,, 1883	4,247	1,494	5,741
,, ,, 1884	4,370	1,503	5,873
,, ,, 1885	4,512	1,515	6,027
,, ,, 1886	4,740	1,524	6,264
,, ,, 1887	4,972	1,542	6,514

Appendix II.

Year.	Miles of wire.	Public messages.	Receipts.	Expenditure.
1870—71	68,998	9,850,177	£612,301	£350,376
1871—72	87,719	12,473,796	735.390	496,694
1872—73	105,285	15,535,780	973,332	833 908
1873—74	108,553	17,821,530	1,049,162	956,170
1874—75	109.778	19,253,120	1,167,745	1,081,937
1875—76	113,216	20,973,535	1,287,623	1,106,912
1876—77	113.333	21,726,143	1,328,315	1,208,401
1877—78	114,009	22,171,867	1,352.668	1,227,560
1878—79	114,242	24,459,775	1,369 467	1.161,551
1879—80	114,902	26,547,157	1,469,795	1,173,287
1880—81	121,052	29,411,982	1,633,886	1,308,453
1881—82	126,734	31.345.861	1,654,390	1,440,498
1882—83	132,456	32,092,026	1,768,070	1,583 876
1883—84	140,499	32,843,120	1,789,223	1.808 920
1884—85	155,568	33,278,459	1,784,414	1,820,764
1885—86	170,196	39,235,813	1,787,264	1,832,401

Appendix III.

Return Showing Number of Press Messages dealt with during one week, in the years 1871, 1879, 1882, *and* 1887, *i.e.*, 1-52*nd part of the number for the year*

	1871.	1879	1882.	1887.
Number of copies delivered	32,413	49,458	57,783	82,459
Number of words in forwarded messages, by day	158,173	195,503	273,610	316,498
Number of words in forwarded messages, by night	334,897	971,439	914,754	1 150,316
Number of words delivered	3,598,380	5,887,129	6,557,045	9,256,315

This does not include prepaid press messages. It only includes messag s sent under "Passes" and under "Services."

Appendix IV.—*Submarine Cables.*

Government Administrations.	No. of Cables.	Length in naut. mls.
Germany	35	461
Austria	31	96
Denmark	36	123
Spain	3	125
France	46	3,197
Great Britain and Ireland	104	876
Greece	45	457
Italy	22	613
Norway	236	228
Netherlands	20	59
Russia in Europe and the Caucasus	5	201
Sweden	9	61
Turkey in Europe and in Asia	8	330
Cochin China	3	810
British India, Indo-European Telegraph Department	5	1,713
,, ,, Indian Administration	67	155
Japan	11	55
Russia in Asia	1	70
South Australia	5	49
New Caledonia	1	1
Dutch East Indies	1	31
New Zealand	3	196
British America	3	200
Brazil	19	19
Total	719	10,142
Companies.		
Submarine Telegraph Company	10	803
German Union Telegraph Company	2	1,119
Hamburg-Heligoland Telegraph Company	2	40
Direct Spanish Telegraph Company	2	699
Spanish National Submarine Telegraph	5	1,172
India Rubber, Gutta Percha, and Telegraph Works Company	2	122
West African Telegraph Company	11	2 825
Black Sea Telegraph Company	1	351
Indo-European Telegraph Company	2	14
Great Northern Telegraph Company	20	6,108
Eastern Telegraph Company	53	18,838
Eastern and South African Telegraph Company	5	4,554
Eastern Extension, Australasia and China Telegraph Company	21	12,635
Anglo-American Telegraph Company	15	10,437
Direct United States Cable Company	2	2,933
Compagnie française du télégraphe de Paris à New York	4	3,409
Western Union Telegraph Company	4	5 537
Commercial Cable Company	6	6,947
Brazilian Submarine Telegraph Company	6	7,325
African Direct Telegraph Company	7	2,739
Cuba Submarine Telegraph Company	3	946
West India and Panama Telegraph Company	20	4,119
Western and Brazilian Telegraph Company	9	3,801
River Plate Telegraph Company	1	32

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Brought forward	213	.....	96,946
Mexican Telegraph Company	2	.....	709
Central and South American Telegraph Company	9	.....	3,178
West Coast of America Telegraph Company	7	.....	1,698
Total	231	.....	102,531

SUMMARY.

OFFICES.	No. of Cables.		Length in naut. mls.
Government Administrations	719	.....	10,142
Private Companies	231	.....	102,531
Total	950	.....	112,673

TACTICS AS AFFECTED BY FIELD TELEGRAPHY.

Two interesting papers on "Field Telegraphy" were read by Colonel L. Hale, R.E., and Major C. F. Beresford, R.E., at the meeting of the United Service Institution on the 20th inst., abstracts of which are given below:

In the course of his remarks, Colonel LONSDALE HALE said it was an accepted fact that the successful conduct of the operations of strategy was greatly facilitated, and in some cases only rendered possible by the existence of telegraphic communication between the supreme strategical leader and his subordinates, and some little time ago it occurred independently to some of his brother officers immediately connected with the telegraphic work of the corps and to himself that if, in the operations of tactics the same kind of communication existed, similar advantages would be gained, and the leading rendered more effective. There was no conceivable reason why the supreme commander of any tactical operation should be, as at present, a nominal commander only. With him, on his shoulders, lay the responsible task of conceiving and drawing up the plan of operations. Why might he not control generally the conduct of these operations? Why might he not determine what modifications should take place in it during its execution? One of the most generally acknowledged weak points of modern warfare was the rapidity with which troops passed out of the control of their commander. There seemed to be an idea that tactical operations must necessarily be conducted on an entirely different principle from that which governed all other military operations, and must be a sort of Donnybrook Fair from commencement to finish. But, surely, there was a judicious mean between close centralisation and unbridled licence. Colonel Hale afterwards reviewed the operations of the German army in 1870-1, and pointed out how circumstances would have been changed if army corps had been in telegraphic communication.

After some preliminary account of the invention and progress of the telegraph for civil purposes Major BERESFORD said:—

The third of a century has just gone by since, in March, 1855, the first field telegraph in war was laid in the Crimea, and as to the British army belongs the honour, so let us trust that the British army will show the way in the future development of the speediest and safest of messengers. Those who have watched the gradual growth of war telegraphs in the British army must have observed the great progress made of late years, and the great and increasing reliance which is placed upon them. Looking away from our own army to the armies of other countries, we see a similar progress going on, and in all we see the desire to extend the telegraph to the utmost limits of active operations. This is very clearly pointed out in a most interesting article in the "Jahrbücher" of the German army and navy for February and March of the present year; the article is by Herr von Fischer Treuenfeld, who shows how by their latest organisations and by the increasing proportion of light cable now being adopted in all armies, a more extended use of the telegraph is clearly foreshadowed. General von Chauvin, the Director-General of Telegraphs in Germany, in his work on the army telegraphs, states that their tactical use during the war of 1870-71 was only prevented by the fact that there were no telegraph troops that had been trained for the purpose during peace. But it had been clearly recognised in Germany before the war that the telegraph could be used on the battle-field itself. In the French army there is not only outpost cable provided, but each cavalry regiment has six telegraphers, with suitable equipment, for establishing intercommunication in the cavalry divisions, and for destroying or repairing the lines of the country. Russia has also an organisation for cavalry telegraphers. The whole telegraph equipment of Spain is of light cable carried on pack animals, and is organised with a view of pushing the electric communication to the utmost limits. Italy, Austria, Belgium, Sweden, America, have all their outpost equipment.

But now we come to the fact, that in spite of all the preparations, there are only a few isolated instances of any tactical use having been made of the telegraph, and I am not aware of its having been thus used to any extent during the great peace manœuvres of Continental armies; for this there must be some cause which universally hinders the progress. Apart from a certain prejudice existing in many armies against a too extended use of telegraphs, the cause is not far to seek. To be efficient, a field telegraph must be reliable; and hitherto no organisation and no instruments or wire for outpost work have been introduced into active operations, at least in foreign armies, that give reliable results; commanding officers have not cared to deal with an uncertain subject. The feeling, so widespread in our army, that the telegraph could never be made reliable for tactical operations is, probably, an outcome of the unnecessarily faulty equipment with which the telegraph troop was provided some twelve years ago. At that time endeavours were made on many occasions in the neighbourhood of Aldershot to use the telegraph tactically, and though communication was often established by its means between the centre and flanks of one of two contending forces, yet it was discredited by frequent failures on other occasions. The cause of these failures was nothing to commanding officers; their verdict was "the telegraph has failed." Now all this time the telegraph troop had been trying to make bricks without straw, to establish communication through cables which age and long days of drill had rendered rotten as ropes of sand, and with instruments wholly unsuited for the purpose. Deaf ears were turned to the remonstrances of those who were in charge, and so the telegraph was discredited for tactical use. We are now in this position, that we have surmounted the two chief obstacles that confronted our advance, *i.e.*, the want of suitable instruments and suitable wires. The field telegraph instrument almost universally used on the Continent is the Morse recorder, in one form or another. The sounder is essentially the British and American instrument; any recording instrument—that is, an instrument in which the signals are received on a tape run out by clockwork—must be delicate, complicated, and unsuitable for rough usuage in the field, and could never be efficient for outpost telegraphy. The chief objections to a cable in the field are, that hitherto it has been heavy, expensive, and, when the wire inside becomes broken from any cause, the fault is difficult to find and repair. Now, Captain Cardew has invented an instrument, a combination of the telephone and sounder, which is simple in construction, and so sensitive to the electric current that it will work in all weathers, through common bare wire lying on the ground. On the other hand Messrs. Siemens Brothers have produced a cable so much lighter and so much stronger than former cables, that it will be almost unnecessary to have recourse to bare wire except as a matter of cheapness. During the campaign on the Nile a very considerable use was made of Captain Cardew's earlier forms of instrument which was worked through bare wire lying on the ground for many miles. Since then the use of such lines has been largely extended in Egypt. The two principal purposes which outpost telegraphs would be used for are—(1) Obtaining information. (2) Transmission of orders. And for these purposes they might be used in connection with—(*a*) Outposts; (*b*) Reconnaissances; (*c*) On the field of battle. With outposts, lines might be run as opportunity occurred from the reserves to the supports, and from the supports to the piquets. Short and still lighter lines might extend from piquets to special posts, or accompany reconnoitering patrols. With reconnaissance by cavalry or infantry, light lines might accompany as far as possible according to circumstances. On the field of battle lines might raidiate from a central station, say the advanced station of the trunk line, to the different points in rear of the position. A second radiating circuit might be run from centre to the artillery positions, not only for the purpose of controlling artillery fire, but also to serve as an alternative line in case of accident to the other wire.

I now come to the matter of organisation, and this at once opens up a fundamental question, *i.e.*, Would outpost telegraphs be best served and carry with them most success if worked by a special telegraph corps, or by a regimental organisation? The trunk lines of telegraph from base to advanced guard, and connecting army corps, divisions, and brigades, are essentially an engineering service, and both officers and men require a long technical training, not only to enable them to deal with the engineering points, but also for the management of what is often a most intricate matter of organisation. The instrument clerks, moreover, on the main lines must be the best that can be obtained, in order to cope with the immense mass of traffic. But on the proposed outpost lines, when the same methodical system would not be required, and messages in great numbers would not be passing, a much lower technical skill would suffice. In making this statement it must not be understood to mean that the higher the technical skill the efficiency of the service would not also be greater. For the more the duties of a telegraph clerk have become a second nature to him the less is he subject to excitement and flurry in emergencies. As regards the proposed organisation for regimental outpost telegraphers, each regiment of cavalry or infantry might have ten trained telegraphers (who would also be regimental visual signallers), an equipment of from one and a-half to two miles of light cable, and three or four sets of station material; the whole to be carried on pack animals, or in a light one-horse cart. The weight of cable such as lies before you being about 70lbs. per mile, two miles would be 140lb. Four instruments would weigh about 30lbs. The necessary batteries and other equipment, about 100lb.; taking 200lb. as a load for one animal, two pack animals would be required to carry everything, weight of forage, blankets, saddles included. A light one-horse cart would doubtless be much the more serviceable mode of transport. The French cavalry equipment is all carried in light one or two-horse carts. The Spaniards carry all the telegraph equipment on mules, with a maximum load of 320lb. They are quite satisfied that their experience proves that field cable is reliable under all circumstances.

I would sum up the points for discussion as follows, asking you to take it for granted that the physical difficulties to outpost telegraph lines are overcome. 1. Is it desirable to extend the telegraph to the utmost limits of an army in the field, if circumstances would admit of it? 2. Would an organisation for giving effect to this be better carried out regimentally or by the Telegraph Battalion? 3. If the principle of outpost telegraphs is admitted, is not the nature of the service distinct from that of the main lines connecting the various parts of an army, and if the outpost telegraphs are regimental, should they not be carried out by the regimental signallers, who should be trained accordingly, while the signallers for the main lines should be highly skilled telegraph clerks, and belong to the Telegraph Battalion?

After the discussion, Lord WOLSELEY, who presided, said that telegraphy had a great tactical future for England, and the nation that would first adopt a system of telegraphy in the field during action would have on its side a force which would give it many chances. He himself believed in novelties. What Napoleon had said was true, that you must change your tactics frequently. But the difficulties of doing so were not fully appreciated outside the charmed circle of official life. The necessity for guns could be shown, and advice might be given on all hands that

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proper organisation would need corps of cyclists and other things; but he should like those who suggested these things to have to go before the Secretary of State for War with their views; then they would get the answers to why these things were not adopted. Why, even the state of our forts at home and abroad, owing to neglect, was most discreditable to the nation and to every one responsible. When the facts were laid before the authorities, it did not matter whether it was a question of guns, of repairs to forts, or the provision of new facilities of communication or anything else, the same process went on. First, there was a large expenditure of pens and ink on the part of some, and of patience on the part of others. One gentleman would write a minute upon any subject to a gentleman, his friend, in the next room, and after the repetition of this process the matter would at last get to the hands of the Secretary of State for War, who, advised by his financial friends, at once told the army advisers that there were no funds. If the army authorities asked for requisites for the army, they were told that they must "economise" in some way to get them. If machine-guns were asked for, then the reply came that the fighting men must be reduced, or, under the same conditions, carts and horses which were necessary for any army would be supplied. If the country went on longer in this way—knocking off cavalry and artillery whenever increased expenditure was required—the army would soon be reduced to two men and a boy. There had been an earnest endeavour made on the part of the army authorities, as all connected with the army knew, to organise a force which might, from necessity, have to be sent abroad—two army corps and one cavalry division. So far as the men were concerned, he was justified in saying that the men could be got ready to be put on board the ships before the ships could be got ready, and the nation could thus be defended from an enemy by striking that enemy elsewhere. But it was of no use talking of the necessity of providing novelties like telegraphs, when the army had not even stores or transports. Most important as it was to have such things as telegraphs, the army felt it was of no use asking for them when it was thus deficient in the first means of moving. He cordially agreed with all that had been said as to the importance of having telegraphs for the army; and he would ask the meeting to thank the lecturers and all who had taken part in the discussion.

COMPANIES' MEETINGS & REPORTS.

London Platino-Brazilian Telegraph Company (Limited).

The ninth ordinary general meeting of the shareholders in this Company was held at Winchester House, 50, Old Broad-street, on the 23rd inst., under the presidency of John Pender. Esq.

The SECRETARY (Mr. William Payton) read the notice convening the meeting and the minutes of the eighth ordinary meeting, which were approved by the present meeting and signed as correct by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: When I last had the pleasure of addressing you I referred at some length to the negotiations which were then going on between the Western and Brazilian Company and this Company. I am not in a position to-day to say that those negotiations have advanced in any way. The Brazilian Submarine Company have had a battle to fight with the Brazilian Government, and, so far as I can see at the present time, that question has also been placed in abeyance. There was an attempt to get an opposition company, and no doubt that opposition company would have materially interfered with the Brazilian Submarine Company and, consequently, with the Western and Brazilian Company. So far, therefore, as these negotiations are concerned, we may say that they are in abeyance at the present moment. I am pleased to say that our position in the meantime has very materially improved, and, as you can very well understand, an improved position gives us a better opportunity, when negotiations are resumed to maintain our interests. We are in a better position now than we have been at any time since these negotiations were opened. You will observe that the receipts from cable messages to the end of December, 1886, were £13,420, as compared with £8,614 in the previous year, showing an increase of 55 per cent. The land lines revenue account shows a very considerable increase, and after deducting all outgoings we have a net profit on that account of £7.559, as against £3,537 in 1885, or more than 100 per cent. increase. That, gentlemen, is a very marked increase indeed, and if this Company, when originally founded, had been established on such principles as we should found it on to-day, there would be a very satisfactory return upon both our cable and land lines. Unfortunately, however, this Cable Company, when it was formed, was saddled with very large amounts which never went either to construct cables or land lines. However, as you are aware, we rescued this affair practically from wreck and ruin, and I am pleased to say that I think we have now placed it upon a very fair and firm foundation. We are very much indebted to our manager in Uruguay, Mr. Lanza, and also to the staff under his command. Our last accounts from him were to the effect that he had travelled on horse-back with his line men over something like 900 miles. He reports our lines to be in a very efficient state, and that is to us not only assuring but also very gratifying. As you know, a submarine or land line system, to be useful in every sense, must be maintained in a thorough state of efficiency. Our cables are also in good working order. I am glad to state that Mr. Lanza from his position there seems to have an influence with the Government, and that we are getting fairly paid for the work we do for the Government, and that is considerable. At one time we were disposed to look on the large amount the Government owed us as not being a very good asset. We have realised that to a very large extent, and consequently we are financially in a sounder and much better position. Since the present Board have been in office they have been able to distribute in dividends about £64,000, and the average dividend for the last seven years has been close upon 2½ per cent. This year we are able to pay 3 per cent., and we hope with good fortune to have a continuance of a fair dividend. With these remarks I beg to move the following resolution—"That the report and accounts for the year ended 31st March, 1887, submitted to this meeting, be and they are hereby received and adopted, and that a dividend of 4s. per share be declared, payable this day (free of income-tax), making, with the interim dividend already paid, a distribution at the rate of 3 per cent. per annum."

Captain FRANCIS PAVY seconded the motion.

The CHAIRMAN: Before I put this motion to the meeting, if any gentleman has any question to ask I shall be happy to answer him.

A SHAREHOLDER: Can you tell us anything as to the prosperity of Uruguay? You would be better informed than we are.

The CHAIRMAN: Well, I have always said that there is no better barometer of trade or progress in any part of the world than that shown by the telegraphs; and, as I have mentioned to you, our increase has been very considerable.

Mr. W. GRIFFITH wished to be informed of the state of the dispute between the Company and the Western and Brazilian Company. With their dividend and their business increasing, perhaps a little more confidence would be inspired in the public if they were not in danger of getting into litigation with any other company, although, of course, the shareholders must support the Directors in upholding the rates. From the balance-sheet it appeared that the contract with Messrs. Lamas and Co. had not been fully carried out. It would be a good thing if that matter could be wiped out, and they could present the public with a clean balance-sheet. He saw that they had lost a little by their Uruguay Bonds, which during the present year had advanced considerably. If any of the bonds were still held by the Company, it seemed to him that the present was the time when they might be realised at a fair profit.

The CHAIRMAN: My first reply is to Mr. Griffith's question as to the amount in dispute between this Company and the Western and Brazilian Company. As to that I do not think it would be desirable when negotiations are pending that we should go into the details of the figures. I think as an old lawyer Mr. Griffith will agree with this. As to the contract with Messrs. Lamas, that is a question which we consider practically settled. Any security that exists we hold, and we do not think the company is ever likely to be liable on that account. As to the Uruguay Bonds, we have been singularly fortunate. It is not our business to hold securities of that kind, but to convert them. We had to take these bonds at par, and as far as that fact is concerned, we realised them at a discount. Our sales have always been on the right side.

A SHAREHOLDER: Were not Messrs. Lamas the contractors who laid the cables?

The CHAIRMAN: No, the land lines. He then put the motion, which was carried unanimously. Continuing, he said, I have now to move "That Mr. John Hollocombe be and is hereby re-elected a Director of this Company." I may mention that Mr. Hollocombe has just returned from a visit to the territory over which our lines are connected, and I need not tell you that the information which Mr. Hollocombe has brought to us is in every way valuable. His advice and assistance as a Director are peculiarly valuable from his long residence in those parts and his recent visit there.

Captain PAVY seconded the motion, which was carried unanimously.

Mr. WM. FORD then proposed the third resolution, as follows:—"That Messrs. Deloitte, Dever, Griffiths and Co. be and they are hereby re-elected auditors of the Company at a remuneration of £25 for the year."

Mr. GRIFFITH seconded the motion, and it was carried unanimously.

Mr. WATKINSON proposed a vote of thanks to the Chairman and Directors. He thought they might all congratulate themselves on the improving position and prosperity of the Company. With such able administrators the shareholders' interests would be well looked after.

A SHAREHOLDER seconded the motion, and it was carried unanimously.

The CHAIRMAN: It is a great pleasure to my colleagues and myself to have satisfactory opinions expressed of our management. It is not only our desire to make this Company successful and prosperous, but it is also the desire of all of us who are connected with telegraphy on a broader scale that every link in our great chain should be successful. We thank you very much for your confidence.

The proceedings then terminated.

The Consolidated Telephone Construction and Maintenance Company (Limited).

Report of the Directors to be presented to the sixth annual general meeting of the Company, to be held at the Cannon-street Hotel on Thursday, June 2, at 12 o'clock:—

The accounts for the year ending the 31st March last show a net profit of £8,957. 4s. 4d., which, with the amount carried forward from last year, leaves a balance of £10,127. 8s. 6d. for disposal. The Directors propose to deal with this amount as follows, viz.:—to pay a further dividend of £2. 10s. per cent, making, with the interim dividend paid in November last, 5 per cent. for the year, writing off the sum of £558 for depreciation of plant and machinery, and furniture, thus leaving a balance of £1,695. 18s. 5d. to carry forward. The amalgamation of our subsidiary company, the River Plate Telephone and Electric Light Company, with the United Telephone Company of the River Plate has become an accomplished fact. As a consequence of this amalgamation, the shares held by this Company in the late River Plate Telephone Company have ceased to exist. The Directors have received £19,877 in

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cash, in payment of the debt owing to the Company by the late River Plate Telephone Company, also £1,250 as compromise for a contract which that company had failed to fulfil for the supply of telephones. The cumulative 9 per cent. dividend amounting to £1,838 17s. 10d. up to 31st January, 1886, has also been paid to the Company, and an amount standing in the books at the sum of £9,256 has now been converted into £8,985, in shares in the United River Plate Telephone Company (Limited), at par, and £11 564 in cash has been received, which amount is now available for distribution. A further considerable amount has to be received in connection with the amalgamation. Out of the amount of capital returned to the Company under the above-mentioned arrangements, the Directors propose to dispose of £11,242. 10s. by returning 1s. per share from the issued capital of the Company, thereby reducing the nominal value to 14s. They also propose out of the amounts received to write off from the good-will and patents accounts the sums shown in the statement accompanying the report. The Directors have done all in their power to extend the sale of the Company's manufactures abroad, and with this in view they exhibited at the Exhibition of Telephones, held in Brussels in the early part of this year. It was admitted on all hands that the articles manufactured by this Company took the first place, and the Board trust that good results will follow. Every effort has been made to keep down the working expenses, and but for the exceptional causes of the Belgian law suit, and the action which Colonel Gouraud has brought against the Company, the present year's charges would have been less by a considerable sum than last year. This action against the Company has been postponed from time to time, and at his further request the trial has now been postponed till after the 1st June next. Colonel Gouraud has also thought fit to commence an action against the Directors for the course they have pursued, with your sanction, in co-operating with the Edison Gower-Bell Telephone Company in the action to prosecute infringers of their patents in Belgium. Thus far, in Belgium all has gone on favourably to this Company, though every obstacle has been thrown in our way. It is impossible to foretell what the result will be should the suit be decided in our joint favour. It may, however, be stated that the damages claimed involve a very considerable amount. Negotiations are also proceeding by which the business of the Edison Gower-Bell Telephone Company in Portugal will be considerably improved. The Directors have now purchased the entire machinery of the American Telephone Company, which was in use in the Company's factory, for the sum of £2,300, thus placing the establishment in a most perfect and independent position with regard to their manufacturing capability. The business of the subsidiary companies, in which this Company is so largely interested, continues to make satisfactory progress. The Telephone Company of Austria at the end of March, 1886, had 1,373 subscribers, representing a gross annual rental of £9 258. At the end of March, 1887, there were 1,791 subscribers, with a gross income of £11,682, showing an increase of 418 subscribers and £2,424 on the annual rental. The Edison Gower-Bell Telephone Company at the end of March, 1886, had in its two exchanges—Lisbon and Oporto—1,105 subscribers, paying a gross annual rental of £6,800. At the end of March, 1887, there were 1,370 subscribers, paying a gross annual rental of £8,778. This shows an increase of 265 subscribers, and £1,978 rental during the year. The increases in the exchanges as compared with 1886 may therefore thus be stated :—

Telephone Company of Austria	418 subscribers	£2,424 rental
Edison Gower-Bell Telephone Company ...	265 ,,	1,973 ,,
Total increase for the year.....	683	£4,402

It is with sincere regret that the Board have to announce the death of one of their colleagues, Mr. John Taylor, whose services proved of great value to the Company. Major FitzGerald and Mr. R. E. Bateman having taken their seats at the Board of the United River Plate Telephone Company, the retirement of these gentlemen from the Board of this Company became necessary as part of the arrangement of the amalgamation. In accordance with the Articles of Association the following Directors retire by rotation, and, being eligible, offer themselves for re-election, viz., C. L. W. Fitz-Gerald, Esq., and Richard Van-Zeller, Esq. The auditors, J. G. Griffiths, Esq., F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and A. E. Green, Esq., also retire, and offer themselves for re election.

An extraordinary general meeting of the Company will be held immediately following the ordinary general meeting, when the following resolution will be proposed as a special resolution, subject to subsequent confirmation :—

"That the capital of the Company be reduced from £243,787. 10s. divided into 224,850 shares of 15s. each and 75 150 shares of £1 each, to £232,545 divided into 224,850 shares of 14s. each and 75,150 shares of £1 each, and that such reduction be effected by returning to the holders of the 224,850 shares that have been issued, paid up capital to the extent of 1s. per share, and by reducing the nominal amount of such 224,850 shares to 14s. each."

Should the resolution be passed by the requisite majority it will be submitted for confirmation as a special resolution to another extraordinary general meeting, which will be subsequently convened.

CRICKET.

EASTERN TELEGRAPH COMPANY v. R. MACKAY AND CO.

The first of a series of matches arranged by the Eastern Telegraph Company to be played this season took place on the grounds of the West London Cricket Club, Wormwood Scrubbs, last Saturday, the 21st inst., their opponents being *employés* in the firm of Messrs. R. Mackay and Co., accountants. The Telegraph Company, winning the toss, elected to go in first, sending in Messrs. A. W. Prosser and J. G. McMillan, who played an excellent game, both hitting hard, and running up the creditable score of 59 ere they were separated. Mr. W. McDonald joined Mr. McMillan; but the "two Macs" were not so successful, McDonald getting clean bowled after augmenting the score by 3. On Mr. G. Jack going in, however, the score again rapidly rose, this gentleman succeeding, by excellent cricket, in putting on 56 runs. None of the remainder, with the exception of Mr. Hensman, made anything of a stand, the innings closing for 155. After a short interval Messrs. Mackay's representatives handled the willow, opening badly by Mr. McMillan disposing of their first man, Mr. R. Finlayson, for 3 runs. The excellent bowling of Mr. MacMillan, who secured 7 of the wickets, was apparently too much for the team, the only member making anything of a stand being Mr. R. H. Hoare, who by careful cricket run up 13. The innings closed for 26, thus leaving the Telegraph Company victorious by 129 runs. We annex the scores :—

EASTERN TELEGRAPH COMPANY.—J. G. McMillan, c. Richardson, b. Head, 37 ; A. W. Prosser, c. Spillwell, b. Head, 25 ; W. McDonald, b. Head, 3 ; G. C. Jack, b. Finlayson, 56 ; C. Hensman, b. Finlayson, 21 ; G. Munro, c. Edmunds, b. Head, 0 ; A. Donaldson, lbw. b. Head, 1 ; E. D. Payne, c. Finlayson, b. McLennan, 1; T. Richardson, b. Finlayson. 1; C. Saunders, not out, 1 ; W. Grigor, b. Finlayson, 3 ; extras 6—total 155.

MESSRS. R. MACKAY AND CO.—R. Finlayson, b. McMillan, 3 ; R. H. Hoare, c. Grigor, b. McDonald, 13 ; W. H. Head, run out, 2 ; R. R. Edmunds, b. McMillan, 0 ; W. J. Stilwell, c. Richardson, b. McMillan, 2 ; C. S. Stuart, b. McMillan, 1 ; R. Murray, b. McMillan, 0 ; G. H. McLennan, b. McMillan, 1 ; H. Limebeer, b. McMillan, 0; C. B. Syer, not out, 0 ; A. H. Cullen did not bat ; extras 4—total 26.

CITY NOTES.

THOMSON-HOUSTON INTERNATIONAL ELECTRIC COMPANY.—The general European office of this company will be transferred to the new Singer building, Admiralitätstrasse and Michaelisbrücke, Hamburg, Germany, on June 1st next.

J. G. STATTER AND CO. (LIMITED).—The business of Messrs. J. G. Statter and Co., of the Alliance Engineering Works, West Drayton, and of Middleton-road, Dalston, has been transformed into a limited liability company, with a capital of £20,000 in £10 shares. The vendors receive £6,400 entirely in shares of the new company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 25.		BUSINESS DONE WEEK ENDING MAY 25. Highest.	Lowest.
Anglo-American	36,	37	36½	—
Do. Preferred	59,	60	59½	58½
Do. Deferred	14½,	15½	15	14⅜
Brazilian Submarine	11,	11½	11½	11 1-16
Cuba	12,	12½	12 7-16	12⅛
Do. Preference	18,	19	—	—
Direct Spanish	2⅞,	3	—	—
Do. Preference	7,	8	—	—
Direct United States Cable	9,	9½	9 1-16	—
Eastern Telegraph	10⅝,	10⅞	10 15-16	10⅞
Do. 6 per Cent. Preference	13⅞,	14½	—	—
Do. 5 per Cent. Debentures, 1899	106,	109	108	—
Eastern Extension	11½,	11⅞	11 11-16	1 ⅜
German Union	10½,	11	11	10⅞
Globe Telegraph and Trust	5½,	5⅞	5⅞	5⅛
Do. Preference	12⅞,	13	14	12⅜
Great Northern	13⅞,	14	13½	13 3-16
Indo-European	34,	35	—	—
Reuter's	7⅞,	8½	8½	8
Submarine	180,	190	188	184½
West India and Panama	⅝,	¾	11-16	—
Do. 1st Preference	8⅜,	9½	—	—
Western Brazilian	7⅞,	8½	8	7⅛
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	104	103

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	⅝	—
Oriental	½,	⅝	—	—
United Telephone	13,	13½	13½	13½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅞,	3⅛	—	— ex new
Do. (fully paid)	4,	4½	—	— ex new
Swan	1⅜,	1⅝	1⅝	1 5-16
Maxim Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36½	36
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	—

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NOTES.

MANOSQUE (BASSES ALPS).—The village of Manosque will shortly be supplied with a central station for electric lighting.

RAILWAY STATION LIGHTING AT BRUSSELS.—The Belgian authorities have had their attention drawn to the imperfect character of the lighting of the Brussels railway stations, and steps will probably be taken to light the three principal stations by electricity.

THE HOLYHEAD CABLE.—The telegraph cable between Howth and Holyhead, containing seven conductors, of which four are defective, is being taken up for repairs, and will be relaid by a more favourable route, the bottom on the Welsh coast being reported unsuitable.

PERSONAL.—Mr. A. A. Campbell Swinton, until recently electrical engineer to Messrs. Sir W. G. Armstrong, Mitchell and Co., Newcastle-on-Tyne, has removed to London in order to undertake the management of the Equitable Telephone Association (Limited), 75, Queen Victoria-street, E.C.

TELEGRAPH STORES REQUIRED.—Tenders are asked by the North-Eastern Railway Company for the supply of telegraph apparatus, wire, and line stores. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York Station, and must be returned by noon on the 7th inst.

BOURNEMOUTH.—Mr. J. J. Norton is erecting at Bournemouth a building which is intended for a free library and school of art. In order that the building may be completed within the Jubilee year the work is being pushed on day and night. Messrs. Mortimer and Shepherd are supplying electric light for the night work.

ELECTRIC LIGHTING AT THE INNER TEMPLE.—Messrs. Drake and Gorham have just completed a considerable extension of the storage plant at the above installation. The new battery is capable of supplying 75 lights for 9 hours, and, we are informed, contains all the latest modifications and improvements introduced by Messrs. Drake and Gorham.

THE KHOTINSKY INCANDESCENT LAMP.—We understand that the German Edison Company has commenced an action for the infringement of its patents against the makers of the Khotinsky incandescent lamp. The head-quarters of the latter company are at Rotterdam, but a factory has recently been established at Cologne, and the lamp has met with some success in Germany.

CENTRAL STATION LIGHTING AT BERLIN.—The Stœtische Elektricitœtswerke Company is about to undertake two new central station installations at Berlin. One will supply light to the district of Dorotheenstadt, and the other will be placed in the old quarter of the city. Each station will be capable of supplying 6,000 16 candle-power lamps from the first start, but an extension to a total of over 10,000 lamps will be provided for.

THE SCHOOL OF ELECTRICAL ENGINEERING, HANOVER-SQUARE.—In addition to the results quoted in our issue of May 20th, the following students, who had previously gained the school's certificate in lighting and power transmission, obtained it also in telegraphy and telephony in a recent examination by Mr. H. R. Kempe, with the following percentages :—Sanders, 100 per cent.; Mott, 96 per cent.; Levin, 78 per cent.; Ryves, 70 per cent.

REPRODUCING.—We have very great sympathy for the troubles of literary men, but we think that a mild remonstrance, if nothing more, is required when original articles are taken from *The Electrician* and credited to our London contemporary, as has been done with the article "On Regulating Series-Wound Transformers" which appears in the American *Electrical Review* of May 21. There can be no difficulty in crediting original articles to the proper source, and we trust that in future our American contemporary will be a little more careful in this matter.

HOTEL VICTORIA, NORTHUMBERLAND AVENUE. — The electric lighting of the Victoria Hotel has been carried out by Messrs. Thompson, Ritchie and Co., of Winchester House, E.C. The plant comprises two pairs of vertical engines by Messrs. Browett Lindley, each engine driving an Elwell-Parker dynamo capable of doing the whole of the lighting required, so that a complete duplication is secured. There is also a set of E.P.S. accumulators for the lighting after midnight. The number of lamps exceeds 1,000. The fittings have been supplied by the Walsall Electrical Company.

SHIP LIGHTING.—The ss. "Earnholm," belonging to the Aberdeen, Leith, and Moray Firth Steam Shipping Company, has been fitted with electric light by Messrs. Andrews and Co., of Glasgow. The dynamo is driven at 650 revolutions by a Tangye high-speed engine, running at 150 revolutions. The ss. "Tantallon Castle" has been fitted with an installation of thirty-five 20 candle-power Swan lamps, supplied with current by a "Kennedy new type ironclad dynamo," run at 650 revolutions. The work has been carried out under the superintendence of Mr. Jas. Campbell, of Mr. Kennedy's firm.

THE UPWARD BATTERY.—Messrs. Woodhouse and Rawson have just completed an installation of this syetem for lighting the private residence of E. Harlock, Esq., at Ely, Cambridgeshire. The plant consists of four Upward cells, with eight columns for holding the chlorine gas, and a set of E.P.S. accumulators of the 11L type. The battery is fixed in the brewery adjoining the house near the mash tun, and immediately below the fermenting tuns—a convenient position, which we are informed could not have been made available but for the entire freedom from smell or noxious fumes from the battery.

INFLUENCE OF ELECTRICITY ON DELICATE WEIGHING.—M. Hennig de Wurtzbourg having noticed some incomprehensible differences in the weights of equivalent quantities, undertook investigations, which showed that balances of precision are often influenced by the electric state of the glass case which surrounds them. This electricity influences the "riders" which slide on the beam of the balance. The error resulting from this influence may amount, it is said, to 600 milligrammes where the case is strongly charged, and two hours afterwards there may still be an error of 10 milligrammes.

A LEAD-IRON ACCUMULATOR.—Under the name of the Kalischer accumulator, a storage cell, with plates of lead and iron, or carbon, has been brought out. The exciting liquid consists of a solution of lead nitrate, the lead plate being amalgamated, and kept in contact with mercury. During the process of charging, the iron plate receives a coating of lead peroxide, which protects it from the solution, the peroxide being, of course, reduced during the discharge. We are not aware what are the peculiar advantages claimed for this cell, although, doubtless, they must be very weighty to compensate for disadvantages which are obvious on the most casual glance.

THE TRANSMISSION OF POWER AT THE MANCHESTER EXHIBITION.—We would call the attention of our readers to the description, which will be found in another column, of the admirable results shown by Messrs. Mather and Platt in the driving of complicated machinery by electric power at the Manchester Exhibition. The complete demonstration of the fact (already familiar to electricians) that electric transmission of power in factories may not unfrequently effect an actual saving in working expense is very noteworthy from the point

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of view of the outside public, and will, we may well hope, lead at an early date to an increased appreciation of the advantages of electrical working, and a correspondingly large increase in its application.

ABANDONMENT OF THE JULIEN SYSTEM AT HAMBURG.—We regret to learn from *La Lumière Electrique* that the annual report of the Tramway Company of Hamburg recommends that the present method of electric traction by means of Julien storage cells shall be given up at the end of the present year. The system is said not to have given such satisfaction as had been anticipated, but no specific fault seems to have been alleged in the report. On the other hand, the Berlin Tramway Company, after examining the working of the system at Cologne, has declared in favour of its adoption. In America also the Julien cells seem to meet with success, so that we should not be surprised to learn that the failure at Hamburg has been the result of bad management on the part of the working staff.

THE NEED OF A PORTABLE ELECTRIC LAMP.—The fatal colliery explosions of last week in England and Scotland have led Mr. Ellis Lever, of Manchester and Colwyn Bay, to renew his offer of £500 for the production of a perfect portable electric miner's lamp within the Jubilee year. More than 50,000 miners have lost their lives by accidents in coal mines during the half century of the Queen's reign. On the same subject a correspondent writes us from Belgium:—"A lamp, giving the light of from 50 to 100 candles for a period of five hours, and not weighing more than 10 or 12lb., with self-contained battery, is in request by the engineers of the Prince Henry Railway Company, Luxemburg, for permitting the inspection of the roof of mine workings. The lamp should be provided with a strong lens and reflector, so that the rays may pierce the dense smoke caused by blasting."

THE DRY PILE.—Prof. Palmieri has recently presented a note to the Academy of Sciences at Naples embodying the results of a study of the so-called dry pile of Zamboni, extending over many years. He arrives at the conclusion that, provided only that care be taken to shut the battery in an hermetically sealed case, the difference of potential will remain absolutely constant for an indefinite period. It is not even necessary to employ any artificial means for drying the air. If the atmosphere remain unchanged this is quite sufficient to ensure the constancy of the pile. The presence of a slight trace of moisture is, in fact, favourable to the development of a higher E.M.F., without impairing its constancy. Prof. Palmieri considers that for maintaining an invariable charge in an electrometer the dry pile, under the above conditions, is far superior to the usual Leyden jar and sulphuric acid arrangement.

THE WRECK OF THE "VOLTA."—Her Majesty's Government have awarded the following rewards to the crew of the boat of the Hellenic steamship "Karteria," which, in circumstances of much risk and difficulty, took off from the rigging of the "Volta" thirteen of the crew of that vessel, on the occasion of her wreck off the island of Mykonos, on April 18th, 1887:—A gold shipwreck medal to S. Vetmis, coxswain, and a silver shipwreck medal each to G. Sarpas, J. Samiotis, C. Micaros, M. Bournias, S. Damulakis, and M. H. Nikiti. Her Majesty's Government have also awarded a binocular glass to Captain J. V. Velissarios, master of the "Karteria," in acknowledgment of his humanity and kindness to the shipwrecked crew on the occasion. We understand that the Eastern Telegraph Company have also made substantial acknowledgements of the bravery displayed by the Greek sailors, and the extreme kindliness of the islanders to the shipwrecked crew.

LIVERPOOL TELEGRAPHIC GRIEVANCES.—The Postmaster-General has sent Sir William Forwood the following letter with reference to the complaints of delay in the transmission of messages between that city and the Continent:—

"Dear Sir William: I write to acknowledge the receipt of your letter conveying to me the resolutions passed at your meeting, together with a report of the proceedings. I can assure you that I fully realise the importance of the question, and anxiously desire to meet, as far as is practicable, the complaints which have been brought before me by Messrs. Hemelyrk and others. At the same time you must bear in mind that my most experienced officers do not recognise the substantiality of some of the grievances to which you call attention. I have this afternoon seen Lord Claud Hamilton on the subject, and have communicated to him my readiness to see you and any other gentlemen interested in the matter with him after the Whitsuntide recess, and he will, I have no doubt, arrange with you a convenient time for the interview.—Yours very faithfully, HENRY CECIL RAIKES."

SODIUM-BICHROMATE VERSUS POTASSIUM-BICHROMATE.—In the American *Journal of Science* Mr. S. L. Harding gives the result of some experiments undertaken to test the comparative merits of the bichromate salts of sodium and potassium. In the first place, for a given weight of solution the sodium salt starts with a very considerable advantage in respect of solubility. At 15° C., water dissolves 12·5 parts of potassium-bichromate and 83·16 parts of anhydrous sodium-bichromate. From this it results that the amount of available oxygen in a saturated solution of the sodium salt is 0·0852 per cent., as compared with 0·018 per cent. for the potassium salt. As a consequence, when two cells are set up containing equivalent weights of material, it was found that a sodium salt cell ran on an average fully twenty hours, or more than one-third longer than the potassium salt cells. The E.M.F. of the two cells is slightly in favour of the sodium, the figures obtained being 1·893 volt, and 1·892 volt. The internal resistance of the sodium salt cell amounted to $0{\cdot}4967\omega$, while that of the potassium salt cell amounted to $0{\cdot}468\ \omega$.

THE BRUSH ARC LAMP AT MANCHESTER.—Mr. W. B. Sayers writes us from Manchester as follows:—"I see among the notes in your issue of the 20th ult. an explanation of the reason why the lamps in the gardens at the Newcastle Exhibition were unsteady, *i.e.*, that they could not be regulated prior to the opening night in consequence of the contractors being late with their work. I should like to draw the attention of your readers to the fact that the whole of the 500 odd Brush lamps now fixed and burning nightly in the Manchester Exhibition have been put together and hung just as they were received from the Anglo-American Brush Electric Light Corporation's works, Lambeth, and that practically none (actually less than 3 per cent.) have required any alteration of adjustment. As a large number of your readers will know that I can claim no credit for this myself, I feel at liberty to call attention to what all who have had any experience with arc lamps will admit to be a very creditable performance on the part of the management and staff of the Anglo-American Brush Electric Light Corporation (Limited)."

CENTRAL STATION LIGHTING IN PARIS.—The company which has undertaken to light the Quartier du Panthéon is making rapid progress in the construction of their central station in the Rue de la Montague-Sainte-Geneviève. The building itself is almost completed. It has been decided to employ dynamos made by Brown, of Oerlikon, and this firm will also supply the whole of the electric material and apparatus. Berthoud-Borel lead-covered cables will be employed, and

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it is intended to lay them under the pavements. The authorisation for this work was obtained from the municipality more than two years ago by M. Marchand, who has disposed of his rights to the new company. This transaction recently gave rise to some discussion at a meeting of the Paris Council, and the principle involved in the sale and barter of rights accorded in the public interest was very properly condemned. No definite action has, however, been taken, and the position of the company in relation to this matter remains for the present somewhat uncertain, although there can be no doubt that the necessary sanction will ultimately be accorded.

A False Alarm.—Much excitement was caused in Vienna on Sunday evening by a rumour that a fire had broken out at the old Burg Theatre, where a performance was taking place. The actual facts were happily not of a serious character. At the new Burg Theatre (a building now in course of construction) a length of about 25 yards of insulated cable had caught fire and burnt itself out. Fortunately the wire was laid along an iron girder, and no further damage resulted. The cable was being used for the charging of accumulators, which are employed to light the men at work in the space underneath the stage. Although so little harm was done, the fact that the fire occurred in a theatre, and was undeniably due to the overheating of a conductor by the current, is doubly unfortunate at the present time. It will be interesting to learn the exact cause of the fire—whether it resulted from the employment of a too small conductor, or from a short circuit, or a reversal of the dynamo current. In either case the lesson should not be lost that, even under the most apparently favourable circumstances, every precaution should still be taken to guard against the possibility of these damaging "accidents."

The American Institute of Electrical Engineers.—We are very pleased to learn that a movement has been set on foot among the electrical community in the United States, which has for its object "to place the American Institute of Electrical Engineers on a firm and enduring basis," and to obtain for the institute a position in the scientific world such as that enjoyed by similar bodies on this side of the water. A further object of the movement is to obtain funds to build a house for the institute. These objects will undoubtedly have the warmest sympathy of the scientific and engineering professions in our own country. From a letter which we have received from two members of the council (Mr. Geo. M. Phelps, jun., editor of the *The Electrician and Electrical Engineer* of New York, and Mr. T. C. Martin, of *The Electrical World*) we learn further that although the movement has only recently taken shape after three years' talk the sum of $4,000 has already been contributed, and—though this is not specifically stated—we have no doubt that any contributions which our readers might be disposed to offer as a token of goodwill would be highly appreciated, irrespective of the actual amount.

The Electric Lighting of Dundalk.—The following paragraph from the *Dundalk Democrat and People's Journal* exhibits the effect produced upon the native—and, as it modestly describes itself, the "untutored"—mind, by the first display of the electric light in the town of Dundalk:—"Last night (May 27th) the town was fully lighted for the first time by the electric agency. The number of lamps agreed upon in the contract were illuminated. The light was clear, brilliant, and steady, and, to our unprofessional eye, the trial seemed a success. 'Tis true that a few of the lights failed to give satisfaction, but this seemed to be the fault of the lamps rather than the current, and therefore should be easily remedied. If Mr. M'Carthy succeeds in his undertaking the result will be a complete revolutionising of the public lighting of towns, and to our untutored mind he is on the high road to success if he has not already arrived there." Mr. M'Carthy, writing at a later date, informs us that since the first night's trial no further difficulty has been experienced in the adjustment of the lamps, and the installation is now working with perfect steadiness. The Town Commissioners have decided to contract for several additional arcs, so as to dispense with the remaining oil lamps in the streets of the town.

Injurious Effect of the Electric Light upon Plants.—According to the Berlin *Centralblatt der Bauverwaltung*, some disagreeable and unexpected results have followed the electric lighting of the Winter Palace at St. Petersburg, which was described in a recent note, the intense brilliancy of the light having been found to cause dire destruction among the ornamental plants used for the decoration of the banqueting halls. It appears that the complete illumination of the rooms for a single night is enough to cause the leaves to turn yellow and dry up, and ultimately to fall off. The damage to the celebrated collection of palms at the Palace is especially serious. It is supposed that the injury is principally due to the sudden change from the sunless days of the northern winter, and from the subdued light of the plant houses to the blinding light of the banqueting halls. It has been shown beyond a doubt that the rapidity of the injurious action, and its amount, are directly proportional to the intensity of the illumination, and plants standing in niches or other places partially shielded from the light are found to remain uninjured. There is no doubt that the injurious effects of the light are greatly intensified by the dry, artificially heated atmosphere of the rooms, and that they would be minimised, if not entirely obviated, if the plants could be surrounded by a steamy atmosphere, such as that in which they are grown.

Liverpool Naturalists and Electric Light Experiments.—The Liverpool Marine Biological Society chartered last week the ss. "Hyæna," belonging to the Liverpool Salvage Association, and sailed for the Menai Straits upon an expedition of discovery and research. The "Hyæna" is supplied with dynamo machinery, and carries a powerful search light at the masthead, as well as some submarine incandescent lamps supplied by Messrs. Siemens. The naturalists found much amusement during the evening in sweeping the Welsh coast with the powerful beam of the search light. The submarine lamp was lowered to a depth of 18ft., and although the lamp itself was lost to sight at less than half that depth, yet the surface of the water was lit up over a considerable area. Unfortunately the special object which the society had in view, namely, a study of the effect of the light upon the denizens of the deep was not realised. This was explained by the fact that the strong tides which run through the Menai Straits sweep the fishes along with them, so that however greatly their curiosity might have been aroused by the unfamiliar glare, they had no opportunity of gratifying it. This was, doubtless, as disappointing to the naturalists as to the fishes, but we cannot see that the latter were to blame. The naturalists ought certainly to have considered the effect of the tidal currents in drawing up the programme of their cruise. We shall hope to hear of better results on their next expedition.

Earthquakes and Electricity.—An Experimental Demonstration.—The following facts have been made the subject of a very careful investigation by the French military authorities, and there appears to be no doubt as to their absolute correctness:—On the 28th February, during the continuation of the disastrous earthquakes in the Riviera, a soldier in the fort of Tête de Chier at Nice, was engaged in

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working a telegraph instrument communicating with another part of the town. At this moment the third earthquake of that morning took place; this was the least violent of the three great shocks. The soldier was thrown from his seat and received a severe *electric* shock through both arms and across the chest. It was some minutes before he recovered the power to move, and he remained in hospital for the rest of the day. As already mentioned the affair has received a most careful investigation, and the French authorities consider the fact to be thoroughly well established. The important question now arises, whether the electric phenomenon is a cause or an effect? In the light of the recent experiments of Prof. Milne in Japan (which will be found fully described on page 409 of our last volume) it will be seen that an earth current may always be looked for as the result of an earthquake, though when we consider the enormous amount of electric energy which must have been in play in order to knock down a man through what was practically a shunt-circuit of comparatively enormous resistance, it is impossible to deny that the electric force may as well have been the cause as the result of the disturbance.

THE ELECTRIC CONTROL OF COMPRESSED AIR BRAKES.—The method of applying a brake to the wheels of railway cars by means of compressed air could easily be arranged to give far more power than it is at present safe to employ if it were possible to ensure an absolutely simultaneous application to every wheel in the train. The methods hitherto adopted do not admit of this. If the brake is applied from the engine, a perceptible interval elapses before the last vehicle on a long train is reached. Hence, with heavy trains, the rapidity of the application of brake-power is limited by the factor of safety necessary to withstand the inertia of the hinder vehicles. The application of electricity to effect the simultaneous release of all the brake-blocks is an obvious resource, and it is perhaps surprising that more has not already been done in this direction. Some experiments of this kind were, however, recently carried out on the Illinois Central Railroad, and are reported to have yielded satisfactory results. Each brake block was supplied with an electro magnet within the air tubes, and so arranged that the application of the current opens the air valves by which the brake is applied. The wires are carried through the tubes, being connected with the metallic coupling pieces at either end, so that no special joint is necessary. An automatic device was also employed to ensure that when off duty the brake blocks shall stand always at the same distance from the wheels. A dynamo upon the engine supplied the necessary current. Some force is evidently required to open the valves against the pressure of the air.

THE WISH IS FATHER TO THE THOUGHT.—The following entertaining paragraph appeared in a recent number of our esteemed contemporary, the *Journal of Gas Lighting*, and clearly betokens a somewhat uneasy, not to say unkindly, feeling in the editorial mind. After giving some account of an installation recently erected by the Gülcher Company in a private house near Petersfield, and to which reference was made in our last issue, the writer proceeds:—"Only thirty-eight lamps are fixed in the house, so that the whole thing is on a small scale. It will be interesting to learn whether, after the novelty has worn off, the purchaser remains satisfied with his bargain. It is very pretty to have a nice house in the country fitted with incandescent lamps, and everything goes on very comfortably for a time. After the contractors' foreman has taken his departure, however, and when the plant has been definitely committed to the care of the "handy man," a change is apt to come over the aspect and performance of the machinery; and in the end it sometimes happens that the electric lighting engine terminates its existence in sawing wood." After all, this sort of thing strikes us as rather superfluous, for, as our contemporary truly remarks, the installation is quite on a small scale, so that the competition of gas lighting in this case (necessitating a private gas works) is entirely out of the question. It can therefore only be "pure cussedness" which gives rise to the ill-concealed aspiration that the electric light engine "may terminate its existence in sawing wood." For ourselves we have never doubted that electricity has a great future in the lighting of country houses.

THE SPEZIA ELECTRIC LIGHTHOUSE.—The *Standard* of the 2nd inst. contains the following letter, over the initials "C. P. S.:"—"Sir: In the course of an interesting discussion at the Institution of Civil Engineers, in December last, on the Electric Lighthouse of Tino (an islet at the mouth of Spezia Bay, opposite the beautiful promontory of Porto Venere), it was stated, as an instance of the extraordinary visibility of that light at long distances, that during the official trials in April last year the rays of its flashes (a group of three flashes every half-minute) illuminated the clock on the Tower of Volterra, no less than 75 miles distant and at an altitude of over 2,000ft. above sea level, casting a distinct shadow on the disc. The Tino light, of five to six million candle-power, is one of the most powerful in the world, and was put up early last year under the direction of Cav. L. Luiggi and the late Comm. Parodi, of Geneva, on behalf of the Italian Government, the optical apparatus and machinery having been supplied by Messrs. Chance Brothers and Co., of Birmingham, according to the design of Dr. John Hopkinson, M.I.C.E., F.R.S. I have lately had frequent occasion to observe the wonderful illuminating and penetrating power of that light from various points of the Tyrrhenean littoral, and in all weathers. Thus, from a point three thousand feet above sea level, in the Carrara Mountain range, from which, on a clear night, even the oil lights of Viareggio, Leghorn, and of the islands of Capraja and Gorgona are visible, the flashes of the Tino light shooting across the sea may be seen illuminating the whole coast of the marble district and the lower slopes of the mountains with almost magic effect. Seen from the pier of Viareggio, thirty miles distant, the brilliancy of the light is positively dazzling, and the shadow it casts of the Viareggio Lighthouse, or of persons walking on the pier, is distinctly observable. Nay, even in the intervals between the triple flashes, the light is clearly visible to the naked eye in the shape of a red spot just about the size and brilliancy of the old Tino oil luminary. Again, though dimmed by heavy rain and thick fog, as it has been during the last few nights, the triple flash is always clear and unmistakable, and then produces, through the quasi-opaque atmosphere, and at a distance of thirty miles, the effect of the blurred disc of the moon on a small scale. This remarkable penetration power of the Tino light is conclusive proof, not only of how admirably it is designed and suited to its essential purpose as a guiding light under the peculiar atmospheric conditions of the Mediterranean, but also how hazardous it would be to dip—viz., to divert such a light, as has been suggested by some—from the horizon to the nearer sea in foggy weather, forsooth, according to the *bene placito* of the man in charge, on the presumption that in such weather the luminous rays could not reach the horizon, and would therefore be wasted. This presumption is wholly fallacious in the Mediterranean; for in the Bay of Spezia, owing to its proximity to the Appennines, the rainfall is much greater than in other parts of the Tyrrhenean Sea, and banks of land fog can often be seen hanging over the bay and Tino when the horizon as far as Leghorn, Gorgona, and even Corsica is perfectly clear."

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INCANDESCENT LAMP MANUFACTURE.—XVI.

BY J. SWINBURNE.

Exhausting Continued.

A very simple form of pump is the drop-over pump. It is the same in principle as that shown in Fig. 11, except that there is no contraction above E, and the tube is made large from U to E. The flow of mercury is regulated by the tap, and the mercury falls over drop by drop. This is the simplest form to make, and is suitable for amateurs. A development of it is also used by Messrs. Mark Bailey and Co.

If the Sprengel pump is wet, or even damp, it will not work properly; it is therefore necessary to dry the air from the lamp before it reaches the pump. A tube of phosphoric anhydride is therefore inserted. Other drying materials have been tried, but without success. Fig. 13 is a diagram of Mr. Gimingham's form of Sprengel pump, used by the Edison-Swan Company for a long time. It is said to be replaced now by Mr. Stearn's short shaft pumps, but it may

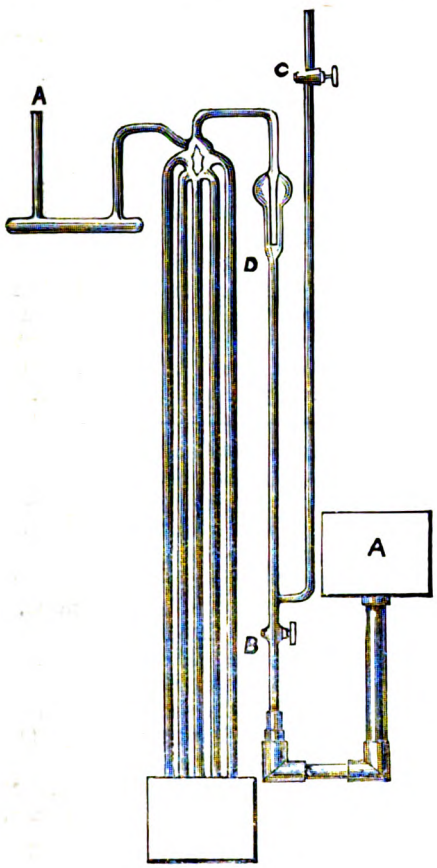
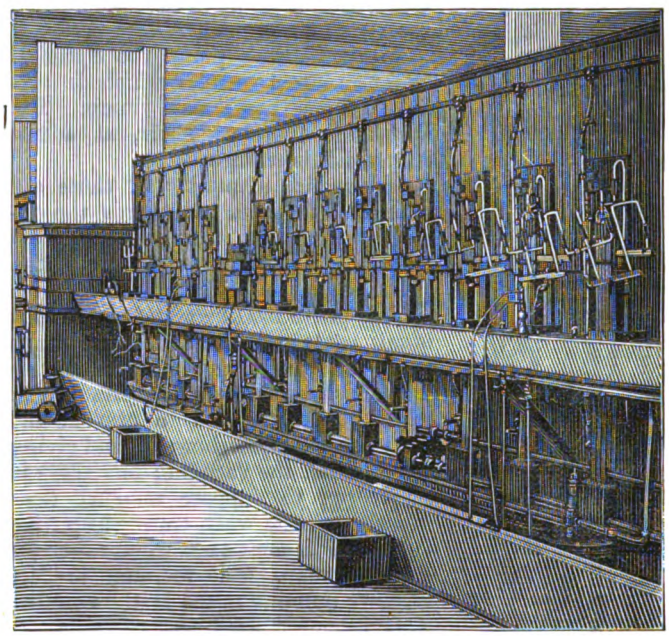


FIG. 13.

be as well to describe it. A is the reservoir of mercury which really supplies several pumps, B is the tap for regulating the flow of mercury, C is a tap on the pipe leading to the mechanical exhaust. An air trap is inserted in the mercury supply tube. Instead of a contraction the mercury passes through five little nozzles or jets, so that it flows in five little streams into the fall tubes or shafts. The top of each tube is large for a few inches, and then the Sprengel shaft proper begins. This is about 40in. long. A tube leads from the pump to the phosphoric tube, which is connected to the lamps. The lamps are not shown. The lower ends of the shafts dip into mercury in a second reservoir. The lower reservoirs of several pumps overflow into one large tank. The mercury is elevated from this to the upper reservoir by a force pump. The force pump is made with no brass exposed to the mercury, and the reservoirs and pipes are made of iron. The force pump has many disadvantages. It dirties the mercury, and it requires a shaft to be brought into the pump room. It is also expensive, and likely to get out of order. The archimedian screw has also been used. Such an elevator consists of a spiral pipe of hard rubber or gutta percha, fixed round a wooden centre piece. This is rotated in an inclined position, with the lower end dipping into mercury, and a shelf to catch the mercury as it comes out at the top.

The writer has introduced the system of raising the mercury by means of compressed air. This has the great advantage that there is no machinery in the pump room, as an air compressor in the engine room is all that is necessary. For raising mercury for a system of Sprengel pumps a closed tank is arranged a little below the level of the overflow from the pumps, so that the used mercury flows into it gradually through a pipe with a non-return valve, which is made entirely of iron. A delivery tube goes from the bottom tank to the reservoir. Compressed air is allowed to flow slowly into the tank, its flow being regulated by a small tap. There is a small valve opening to the air, so that when the valve is open the air from the compressor escapes; but when it is closed the pressure is exerted. This valve is controlled by a float, which rises and falls with the mercury in the tank. When the mercury begins to flow in, the float is at the bottom and the valve is open; when the tank is filled the float suddenly shuts the valve, and the pressure forces the mercury up the delivery tube to the upper reservoir; when the tank is empty again the float suddenly opens the valve and lets the air escape. This elevator was used on a large scale in the Swan lamp works fitted up by the writer in Boston, United States of America. It worked very well. It would have been simpler, however, to have dispensed with the valves and floats, and to have made the flow of compressed air intermittent by an automatic



View of Boston Pump Room.

arrangement such as that used in the writer's pumps, to be described presently. The delivery tube must not be made to rise directly from the tank, as, if it did, when the tank was emptied, the air would force the last of the mercury through with a rush, and would blow through. The delivery tube is therefore led down a foot or so, so that there is an extra head of mercury to resist the air pressure when the tank is emptied.

The above engraving shows part of one side of the pump room fitted up in Boston in 1882. A long partition runs along the centre of the room, and to this 100 pumps are fixed, 50 on each side. The iron pipes are for the air pressure, gas, and vacuum. The pipes were iron gas barrels, and so perfectly was the work done that, in spite of the innumerable joints and connections, on the first trial the Bourdon gauge in the engine room showed a vacuum of 30, and after being left all night the gauge still stood at 30. This sort of workmanship might be copied with advantage by our English plumbers. A Knowles steam vacuum pump was used, with a 10in. cylinder. The compressed air

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was supplied by a small compressor originally made for driving a rock drill. The pumps seen in the engraving are five shaft Sprengels. Each pump has two phosphoric tubes. The shafts are not sealed to the pumps, but are connected by little pieces of thick walled rubber tube, which have been steeped in glycerine, and the branch tubes on which the lamps are sealed are connected in the same way. This method of making joints is bad, and had to be abandoned. Each pump is fixed to its own board, so that when it goes wrong it can be taken down and another put in its place without delay. All the parts of the pumps are made to gauge, so that the pumps are interchangeable. There is an elevator for every sixteen pumps, of which eight are on each side of the partition. A hand blow-pipe, with flexible tubes, is arranged with gas and air supply. The air was taken from the high-pressure pipe, as it was not worth while to lead a special pipe from the glass-blowers' supply. Under the pumps there is a trough to catch any mercury that may be spilled by the breakage of a pump. The whole floor is also covered with linoleum, which is turned up at the walls, so that any mercury that is spilled may be swept up without loss.

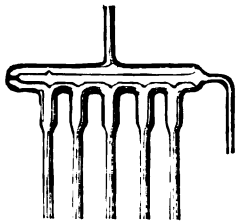

FIG. 14.

Fig. 14 shows an arrangement of the jets—of a five-shaft Sprengel that has the advantage of being much easier to make than Mr. Gimingham's form. It was designed by Mr. Proctor, who was the writer's assistant in Paris in 1882. The horizonal jet tube should have a little hole on the upper side of it, otherwise air is apt to collect and spoil the vacuum when nearly complete.

In Mr. Stearn's pump the Sprengel exhausts into a vacuum which is produced by a mechanical pump. The shafts are therefore short, as a few inches' fall is enough.

In practice a number of these are connected together as regards the elevating system, so that a pump room has a number of groups of eight or ten pumps each.

This pump has the advantage that it is self contained, and that the mercury is not allowed to get dirty, as it does when it flows through a system of iron pipes. It is also said to prevent the mercury from absorbing air, and giving it off under the vacuum; but there is no reason to suppose mercury does absorb air, even when churned up with it, as it is in some cases when raised by a force pump. The mercury in Mr. Stearn's pump is raised by the vacuum. This is not a good way of raising it, as a vacuum is more difficult to manage than compressed air. If compressed air were used in this pump, however, it would have to be made much longer, and that would spoil its compactness, which is its chief charm. The short-shaft principle is due to Poggendorff, who devised a sort of rough short fall Geissler pump; but the introduction of it is due to Mr. Stearn who re-invented it.

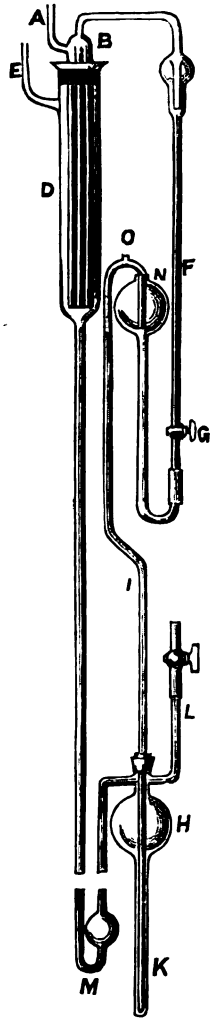

FIG. 15.

Figure 15 shows a modification of Mr. Stearn's pump devised by the writer. This pump was in actual use some time, but it is here described to show how a pressure-elevator may be applied to the Sprengel pump. A is a tube from the lamps and phosphoric tube, the jets are inside at B. There are three shafts about 10in. long. The shafts are enclosed in a wide tube, which has a taper mouth, which is closed by a rubber stopper which fits B. The wide tube D is connected with a mechanical exhaust by the tube E, and when it is exhausted the mercury rises and covers the ends of the Sprengel shafts. When the tube D is exhausted and the tap G open the mercury runs up F and down the Sprengel shafts, and the overflow runs into H. H has a tube I passing through an air-tight stopper in the neck and passing down nearly to the end of the tube K. L is a small tube connected to the intermittent air pressure. When H is nearly full of mercury the pressure comes on. It forces the overflow from the pump back down M till there is enough back pressure to prevent its being forced any further. It also forces the mercury up tube I into the upper reservoir N; the long tube K prevents the whole of the mercury being forced out of I, by producing an opposing head of mercury; otherwise the last of the mercury would be blown round violently, and the compressed air would escape. When the air pressure is taken off, the mercury in M rises and flows into H again, and the mercury in the tube I falls. The opening at O prevents any siphon action which might otherwise occur, as the tube is turned down into N to prevent the mercury splashing.

The drawback to this form of pump is that if the vacuum in D is broken or even reduced a little, the mercury in the shafts is taken round into the phosphoric tubes or into the lamps. The Sprengel part of it is also a little difficult to make. This elevator can easily be applied to any ordinary Sprengel pump, as the tube D may be low down and may thus be open to the air. The writer has made a pump for experimental use in which D was itself the bulb of a Geissler pump; but there is no advantage in combining a Geissler and a Sprengel.

The writer devised a form of elevator some time ago which is interesting as a curiosity. It consists of a sort of inverted Sprengel pump. The top is exhausted and air is admitted through a regulating tap at the bottom in such a way as to carry up plugs of mercury. This works well, but the use of the vacuum is an objection. It might be used with compressed air, but the methods already described are better.

Lightning Conductors for Gasworks.—The destruction by lightning in January last of the large chimney at the gasworks at Fécamp, which was accompanied by several extraordinary circumstances, will be within the memory of some of our readers. The chimney was not provided with a lightning conductor, and in a paper describing the occurrence which was read before the French Society of Civil Engineers, the extraordinary opinion was expressed that such protection would, on this occasion, have been useless. M. Colladon thereupon communicated to the President of the Society a statement to the effect that chimneys in gasworks should always be provided with lightning conductors fitted with powerful tapes for the safe conveyance to earth of heavy charges of electricity. He stated that the destroyed chimney at Fécamp, which was 30 metres high, was built upon a foundation more or less humid from the vicinity of the sea, and containing numerous gas and water mains. In the neighbourhood there were also deposits of coal and coke, the whole forming an admirable ground connection. Under such circumstances, therefore, it was especially desirable that the chimney should be provided with a good lightning conductor connected to earth with special care. M. Colladon instanced a case at the Geneva Gas Works, where a chimney, surmounted by a heavy iron cap terminated in a pointed rod of platinised copper. This rod was in connection with a conducting cable, formed of six strands, each of six tinned-iron wires 2 millimetres in diameter. The cable descended to a depth of 3 metres below the surface of the ground, where it was doubled in several convolutions, which, even in summer, were immersed 2 metres in the waters of the Rhone. In July, 1877, however, the point of the conductor was struck and fused by lightning. At a height of 3·5 metres above the ground, a portion of the charge left the conductor, and spread along the ironwork of the roof of a shed built against the retort-house wall, after which it pierced this wall, which is 60 centimetres thick, displacing a block of stone in the way, to attain the iron gas-pipes which served to light the interior of the retort-house, whereby it finally escaped to earth. Since this event the cable has been supplemented by a better conductor,

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ROWAN'S ELECTRO-MAGNETIC MACHINE TOOLS.

It is often of great convenience to be able to use certain tools in positions where it has hitherto been difficult to convey energy. Of late years the use of hydraulic machinery has, to a certain extent, enabled apparatus to be used in such situations, but it does not fully supply the requirement. Attempts have been made to use electricity for the purpose, and one of the most successful of these is to be found in the apparatus designed by Mr. Rowan, intended more especially for ship work; but of course the apparatus is useful for many other purposes.

The illustrations given on another page are sufficiently exhaustive to explain themselves, and will therefore need little description.

Figs. 1, 2, and 3 show arrangements of framing for carrying and guiding tools. Fig. 1 shows an elevation of frame, carrying a drilling or other machine, and traversing vertically by means of the screwed guides at each side; the machine moving laterally on the horizontal bars or guides of the frame, on which it is carried by a saddle or other arrangement. The frame is attached to the work either by electro-magnets, as shown on the left of the illustration, or by bolts, as shown on the right. This arrangement permits of a considerable area of work being embraced without altering the position of the framing. Figs. 2 and 3 show a plan of a similar frame attached to the side plating of a ship, which is shown in section, alternative methods of attaching the framing being shown at right and left of the figure. At A an electro-magnetic holder-up is shown in connection with a steam riveter, held only by the framing; at B an electric drilling machine, having in addition its own holding-on magnets, is shown, and at C an electric riveter and holder-up, having also their own holding-on magnets, are shown, all moving on the same framing. Fig. 2 shows a plan of guide bars for carrying and shifting the position of machines in such places as under the bottom of a ship, &c., where lifting tackle cannot be applied conveniently.

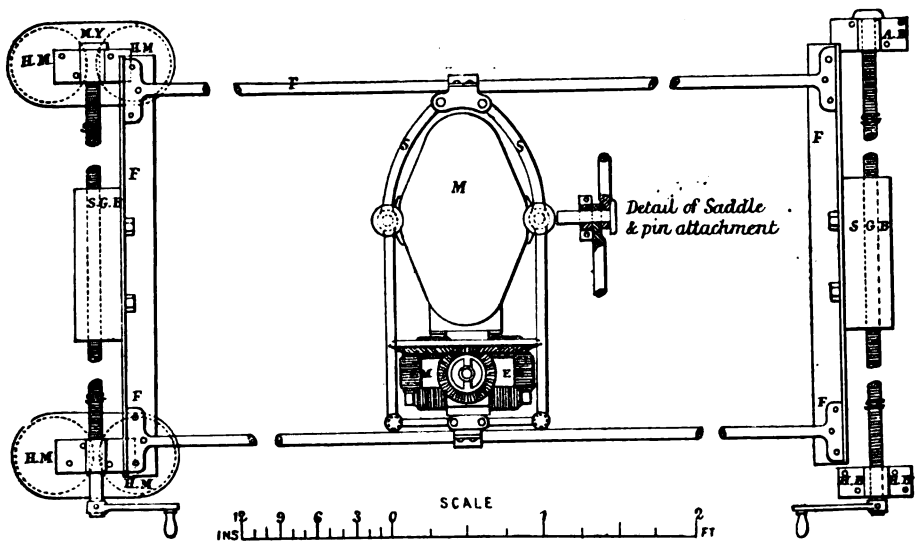

FIG. 1.—Framing for Traversing Tools.

Fig. 4 shows an elevation—partly in section—of an electro-magnetic riveter (the motor being omitted), having holding-on magnets, and a spiral or volute cam, which, through an anti-friction roller on an arm, lifts the hammer rod against a spiral spring, which, when released by the cam, operates to produce the blow of the hammer. The spiral spring is compressed between the hammer head and a disc or plate working in a circular guide box, its position, and consequently the amount of compression given to the spring, being regulated by two screwed spindles working through the top of the guide box, and moved by gearing (omitted in this figure but shown in Fig. 5.)

Fig. 5 shows a similar riveter operated by means of a helical cam (shown in side elevation at Fig. A) which works in the line of the hammer rod between cross heads connected by four rods, to the lower of which cross heads the hammer rod is attached.

Fig. 6 shows in front elevation and in side elevation in section, one form of an electro-magnetic holder-up for riveting. It has a curved arm with a supplementary bolster for application to rivets under reverse-bars of ships' frames or in confined spaces.

The pressure on the rivet head under the main bolster is applied by a strong screw worked by a hand wheel after the holding-on magnets have taken their grip of the plating, and a steel or other spring at the back of each bolster permits of the flattening of the rivet head during riveting, being compensated.

Fig. 7 shows one form of electro-magnetic drilling machines with a single drill spindle, the motor being omitted. Feed gearing is shown, which may be worked by hand or by means of spur gearing.

Fig. 8 shows another arrangement of drilling machine for either a single drill spindle, capable of being traversed horizontally along the frame to which the motor is attached, or it represents a cross-section of a multiple drilling machine, as shown in elevation in Fig. 6 and in plan in Fig. 10, which shows auxiliary holding-on magnets at the back of the framing, but it is not absolutely necessary to use them.

Figs. 11, 12, and 13 show different forms of machines for caulking and chipping.

At A and B in Fig. 11 the tool is shown actuated by an electromotor through gearing, lifting cam, and spring, as in the riveting machine. The other views show (in section at C, Fig. 11, and in elevation, Fig. 13) an arrangement of solenoid coils for producing the necessary effects. At A, Fig. 11, and in both Figs. 12 and 13 each tool is held or supported by its own holding-on electro-magnet, to which it is attached by an arm and traversing screw, and either ball and socket joint, or swivel pin, which allow its position and angle to be altered at will.

At B and C, Fig. 11, the tool frame is arranged to allow it to be used in conjunction with a frame or guide similar to that shown at Fig. 2.

Reference Letters to Illustrations.

H.M.	= Holding-On Magnets.	C.M.	= Contact Maker.
M.Y.	= Yoke of Magnets.	F.S.	= Feed Screw.
H.B.	= Holding-On Bolts.	F.G.	= Feed Gearing.
F.	= Framing.	D.S.	= Drill Spindle.
M.	= Machine.	D.	= Drill.
S.	= Saddle for Carrying Machine.	S.Dr.	= Socket for Drill.
		D.Gr.	= Drill Gearing.
E.M.	= Electro-Motor.	T.Sh.	= Traversing Shaft.
S.G.	= Screw Guides.	G.	= Guides.
S G.B.	= Screw Guide Box.	H.R.	= Hammer Rod.
St.R.	= Steam Riveter.	Sp.C.	= Spiral Cam.
H.U.	= Holder Up.	L.A.	= Lifting Arm.
D.M.	= Drilling Machine,	A R.	= Anti-friction Roller.
E.R.	= Electric Riveter.	G.R.	= Guide Rods.
S.P.	= Ships Plates in Section.	B.G.	= Bevel Gearing.
S. F.	= Ships Frames in Section.	Sp.G.	= Spur Gearing.
R.B.	= Reverse Bars of Ship Frame.	R.G.	= Roller Guides.
B.	= Bolster.	S.S.	= Spiral Spring.
Sp.	= Spring.	S.D.	= Spring Disc.
S.C.	= Screw Compressor.	G.B.	= Guide Box.
H.W.	= Hand Wheel.	A.S.	= Adjusting Spindles.
C.A.	= Curved Arm.	M.F.	= Machine Frame.
G.B.	= Guide Bars.	M.S.	= Motor Sole Plate.
W.G.	= Worm Gearing.	C.H.	= Cross-head.
So.C.	= Solenoid Coils.	C.R.	= Connecting Rods.
C.T.	= Chipping Tool.	C.S.	= Cam Shaft.
S.A.	= Supporting Arm.	C.G.	= Cross-head Guides.
T.S.	= Traversing Screw.	H.	= Hammer.
S.R.	= Striking Rod.	R.P.	= Radial or Swivel Pin.
C.S.C.	= Cylinder Enclosing Solenoid Coils.	L.C.	= Lifting Cam.
		B.S.	= Ball and Socket Swivel.

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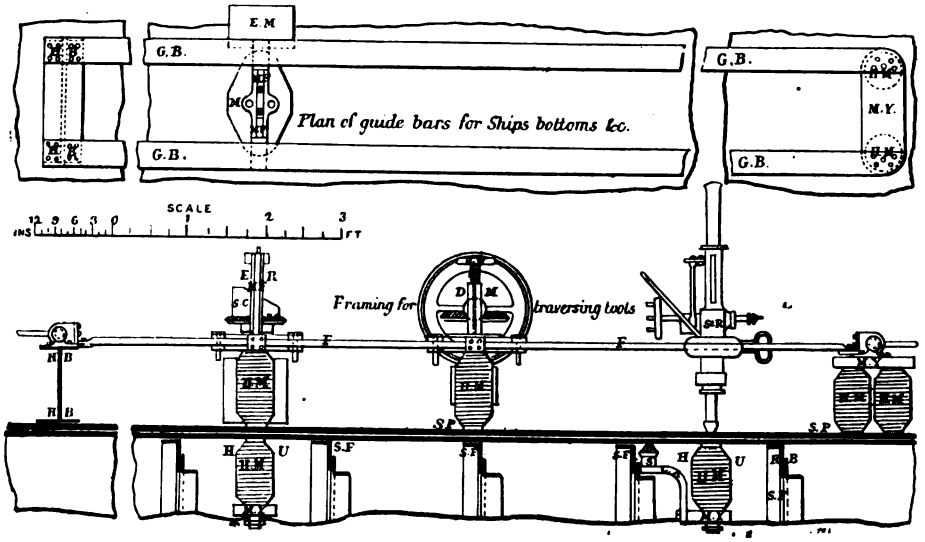
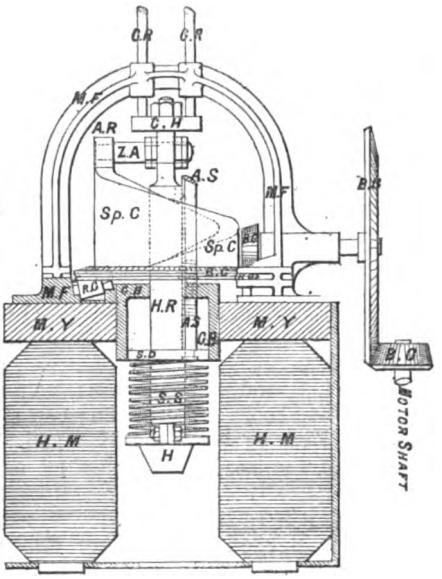


FIGS. 2 and 3.



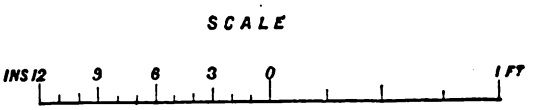


FIG. 4.—Riveter with Spiral Cam.

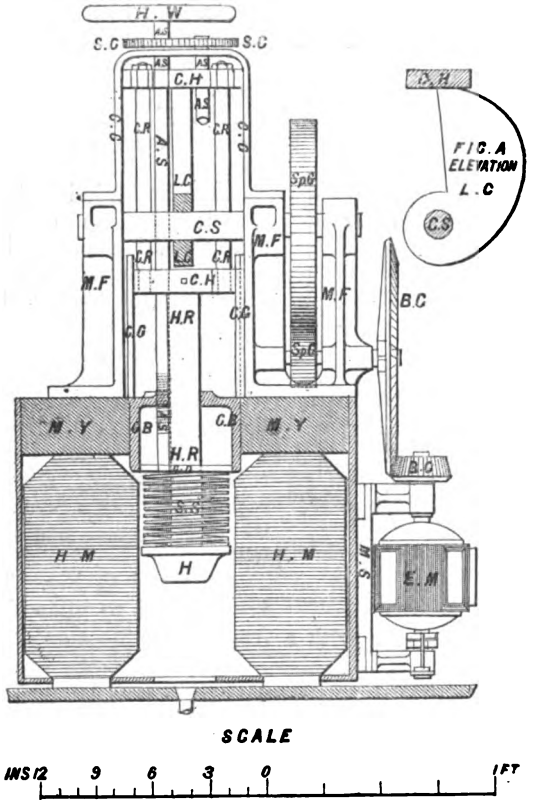


FIG. 5.—Riveter with Helical Cam.

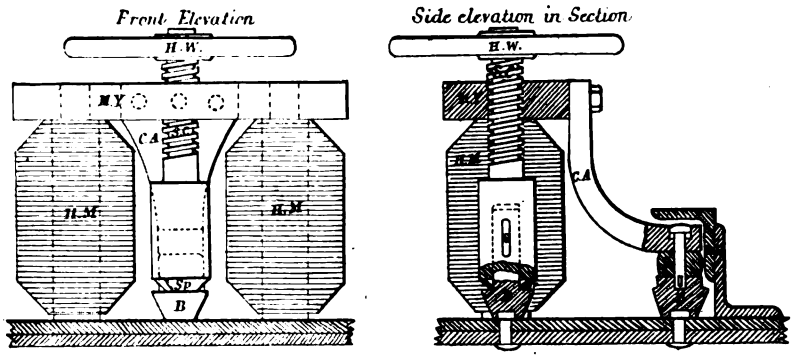


FIG. 6.—Electro-Magnetic Holder-up.

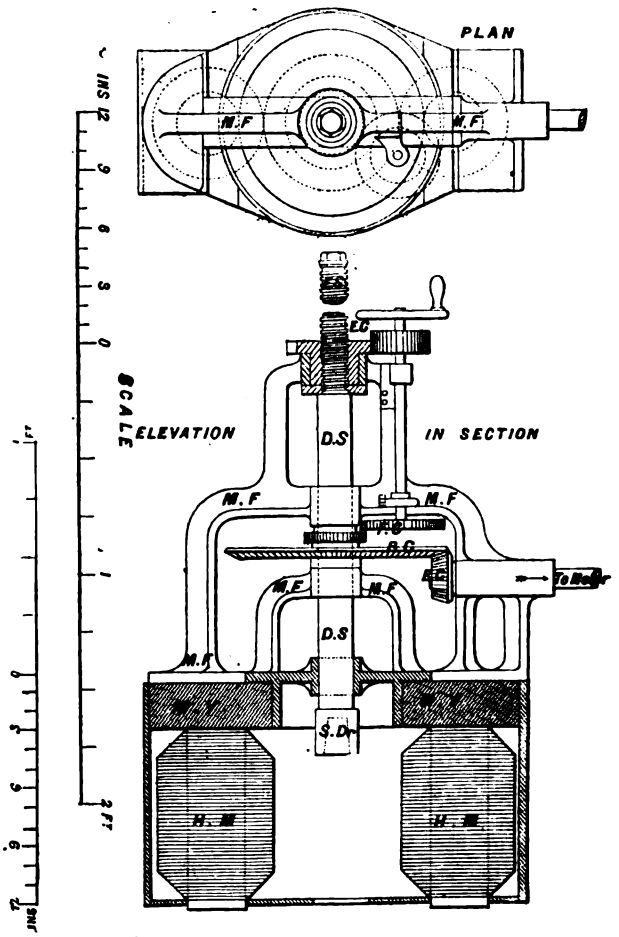


FIG. 7.—Drilling Machine.

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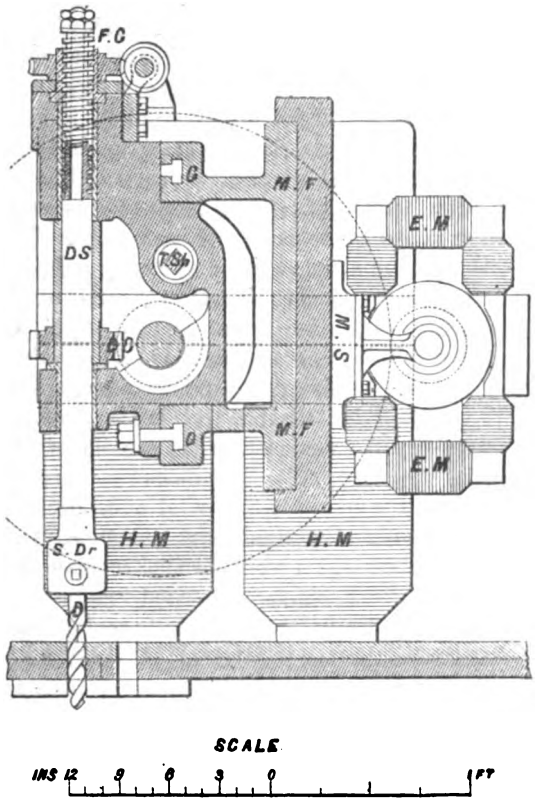


FIG. 8.—Drilling Machine.

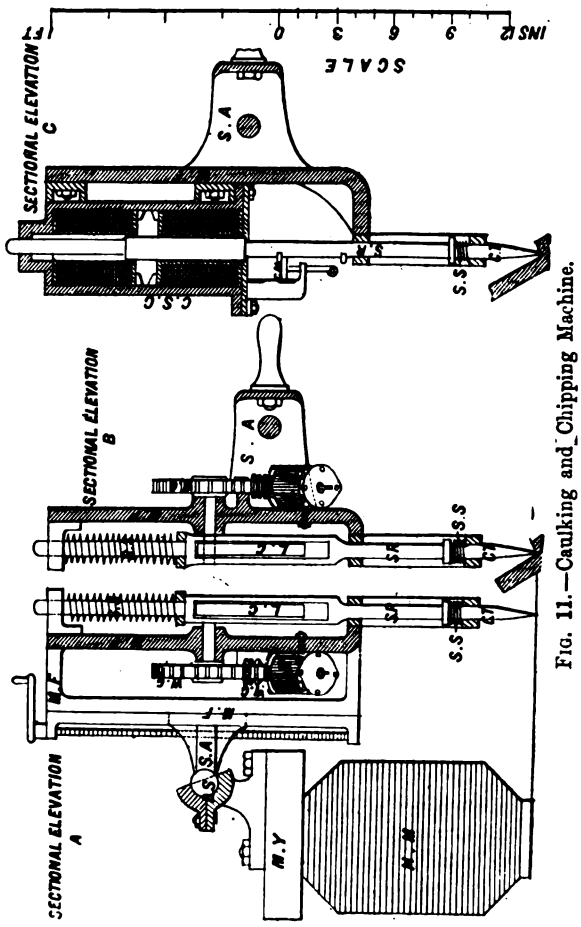


FIG. 11.—Caulking and Chipping Machine.

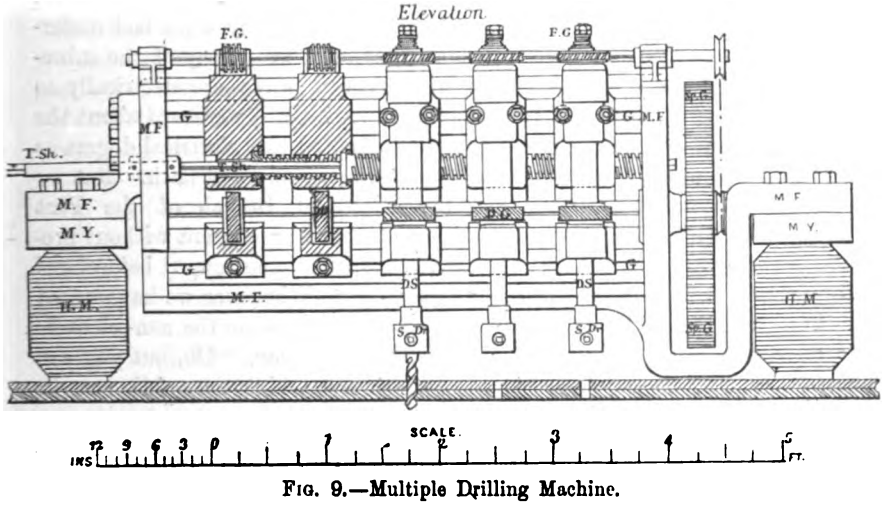
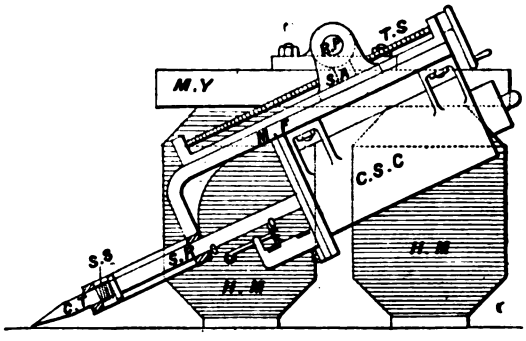


FIG. 9.—Multiple Drilling Machine.



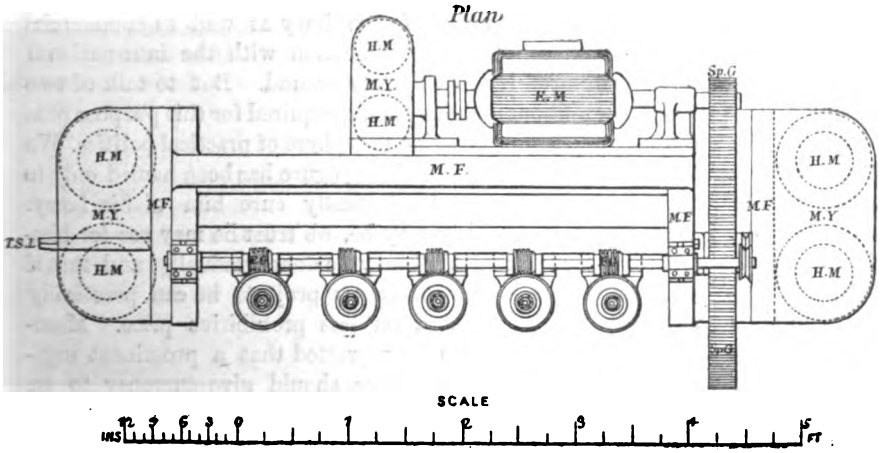
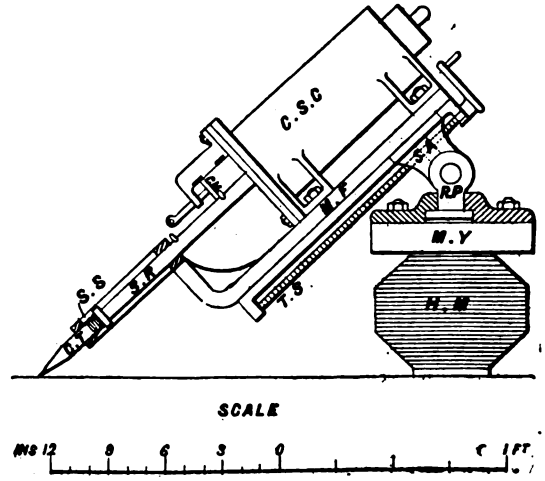


FIG. 10.—Multiple Drilling Machine.



FIGS. 12 and 13.

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THE ELECTRICIAN.

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UNDERGROUND TELEGRAPHS.

Mr. FLEETWOOD'S paper the other evening at the Society of Telegraph-Engineers, although interesting of itself and valuable, perhaps, to those whom it may concern, was disappointing, we suspect, to most of the members present because of the very limited scope of its treatment. A paper on Underground Telegraphs that deals only with subterranean wires in cities and towns is like a paper on Submarine Telegraphs dealing only with submerged cables under channels and rivers. Naturally Mr. FLEETWOOD devoted his time chiefly to a branch of the subject with which he has been associated more closely, perhaps, than any other person living; but something more was expected from the title of his paper, and that something was almost wholly lacking. We say almost, because, apparently with a view of meeting this objection, Mr. FLEETWOOD supplied some very instructive facts with reference to ancient underground cables which he had disinterred in the course of his excavations within the metropolitan area, and which exhibited some features of durability and electrical efficiency that were of a highly encouraging nature. In some instances even the long-distance underground wires of forty years ago, when recently brought to light, were comparatively perfect, or at all events had failed more because of want of care in laying them down than because of any defect in the materials employed for insulation. If the same condition may be anticipated of the ingredients made use of during the last ten or twenty years, with all the improvements and careful superintendence which experience has taught us to be necessary, the Post Office underground wires will have a very long life indeed. But even on this point the paper was not so explicit as one could have wished; and a direct question on the subject addressed to the author during the discussion which followed was, perhaps through missing the point of the questioner, not quite satisfactorily answered. It seems to be the habit of British Post Office officials to assume that everybody will take for granted the work done by their Department to be as perfect as man can make it. This may be the case, but the assumption is liable to be questioned by outsiders, and their reasonable curiosity, as well as their perhaps unreasonable incredulity, should be satisfied.

On the whole, we think there is room for another paper on Underground Telegraphs, and preferably from a quarter less trammelled by official reticence or prejudice. We want to know more about modern underground wires of considerable length, if not in this country, in other countries; at what rate they are capable of being worked with appliances and operators such as we can command in England; whether those wires develop faults as frequently as overhead wires; and what is the probable life of such wires. The cost we do not care so much about, because efficiency and permanency are the chief things to be aimed at; and upon these two points there seems to be a divergence of opinion even among Postal Telegraph officials themselves. Mr. FLEETWOOD stops short just where we expect him to begin, illustrating our remark about official reticence; while Mr. PREECE drops some gratuitous disparagement which is a sample of what we mean by official prejudice. The first-named officer said nothing in his paper on the question, the vital question, of long underground wires—a very significant omission, seeing that he has evidently formed a very decided opinion on the subject. When his official chief expressed an opposite opinion the subordinate firmly but respectfully replied that he believed Mr. PREECE would change his mind. Plainly, one official is confident he could easily lay wires underground from London to Edinburgh that would work as well or better than the overhead wires, whilst equally plainly another official would rather he did not say so—at all events not in public. On this delicate question the higher official has, in all probability, a perfectly open mind, which is at present revealed in his observation that if Parliament will give the Postmaster-General the two-and-half millions necessary to carry out the work, our great centres of commerce and industry will be telegrapically connected by wires laid underground. Indeed! Then what are we to say of the subsequent contention that subterranean wires are electrically so many times inferior to aërial wires? Until we heard about the two-and-half millions we had accepted this electrical dogma as gospel, and have preached it ourselves in good faith. But we cannot suppose that the Electrical Branch of the Post Office Telegraphs would countenance or consent without protest to a scheme of vast expenditure handicapped beforehand with such an electrical dead weight. Whenever we have urged the electrical difficulty in conversation with the non-scientific public their invariable rejoinder has been, "Oh, but you can surely get over that." We begin to think the public may be right after all.

Two millions and a-half is a formidable estimate however, and is suggestive of indefinite postponement. Now, although we have resisted the popular and ignorant clamour for a general underground system whenever the overground wires are interrupted by storm, we have on the other hand advocated certain alternative routes for military as well as commercial reasons, and especially in connection with the international cables, being safely lodged underground. But to talk of two and a-half millions of money being required for this purpose puts the suggestion almost outside the sphere of practical politics. We have heard it hinted that this big figure has been named only to frighten somebody, and effectually cure him of his fancy. Whoever that somebody may be, we trust he may see for himself that work of that kind may be done gradually, and that if he is content with less ambitious projects he can practically have what he desires at a far less prohibitive price. Meanwhile it is, we think, to be regretted that a prominent engineering officer of the Post Office should give currency to an extravagant estimate calculated to have the effect of depriving the public altogether of what they may reasonably demand

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simply because they have demanded more than they actually need.

We cannot leave this subject without according our warmest approbation of the remarks which were incidentally let fall by Colonel WEBBER with reference to overhouse telephone wires. A more sensible and businesslike statement of the case for gradually laying these wires under the streets it would be impossible to have made. Pointing out the almost intolerable nuisance which these wires have grown to be in the metropolis, and the obvious fact that a time must soon come when the public will stand no more of them, he advised that a reserve fund should be accumulated by the telephone companies for the purpose of constructing an underground system similar to that of the Post Office, and ready against the time when patents and public patience alike have expired. That time is not far distant, and the sooner Colonel WEBBER'S advice is acted on the better. Over and over again we have proffered the same advice, only to incur the implacable ill will of the responsible managers of at least one great metropolitan telephone company. Colonel WEBBER, having been himself associated with the enterprise, will be suspected of no journalistic or other prejudice against the overhouse system; and it may be hoped that his words will reach the eyes of the present holders of London telephone shares, if the ears of the managers continue deaf to his friendly remonstrances. Mr. FLEETWOOD'S paper at least was conclusive as to the practicability—and incidentally also as to the economy—of underground wires for telephony not less than for telegraphy. What the Post Office have done a Telephone Company could do; and as to the cost, it has been grossly and wilfully exaggerated. In the second place it must be incurred sooner or later, and the later it is the heavier it will be. It was one of the defects of Mr. FLEETWOOD'S paper that it told us nothing about cost; but although it may suit the Post Office to stagger us with alarming estimates, they do not expend their money on the same magnificent scale; and as their metropolitan wires are nearly all underground, we may safely argue that the process was originally calculated to prove economical in the long run.

CORRESPONDENCE.

REGULATION OF SERIES-WOUND TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of April 9th, in an article on regulating series-wound transformers, you describe the interesting work of Messrs. Sharp and Kent, of Westminster, their plan of operations being the substitution of what you term "induction rings" for lamps in the secondary line of induction coil lines in series.

A point is also made that the energy expended in a coil which replaces a lamp is in reality quite trifling in amount, &c.

I enclose with this letter copies of three United States patents, which were filed March 19th, 1883, May 21st, 1884, and May 23rd, 1884, respectively. An inspection of these patents will show conclusively that they fully disclose the mode of regulation in an alternating current system of any kind, consisting in the substitution of self-inductive coils, or what I have termed "reactive coils" for lamps, the coils being constructed to have a very low resistance, and with a large coefficient of self-induction.

In the earliest of the patents, namely, that filed March 19, 1883, there occurs on line 45 the statement, "I use in my system an alternating line current supplied to the circuit by any suitable generator, or by an induction apparatus whose primary is fed by any suitable generator;" and in line 57 thereafter the statement occurs, "In connection with the lamps or other working resistances of the system I provide a suitable electric reaction device, such, for instance, as an electro-magnet and reactive coil consisting of a bundle of iron wire or other suitably divided or otherwise constructed core, surrounded by a coil of insulated wire, and whose purpose is, when a lamp, motor, or other device is removed from the circuit, to convey only that current that would have kept the lamp burning. The resistance of the reactive coil is made very small, by preference, and it acts not as a substituted resistance but as a real counter electromotive force generator;" and further, in line 81, the description continues, "This device operates after the well-known manner of an electro-magnet in an electric circuit to set up what is known as an "extra" or "counter" current, whose tendency is to oppose a current sent into the coils at the moment it begins to flow." One of the concluding clauses of the specification I may be permitted to quote, as it bears on the question of loss of energy. It is, "In the system as herein described any lamp or lamps may be extinguished by simply replacing it, by its reactive coil or condenser or similar device, and without the loss of energy of current such as occurs when the lamp has a resistance substituted therefor."

The claims, though all relating to this feature of a substituted reactive coil, may be typified by quoting only one—namely, the first. "The combination with an electric lamp or other translating device included in a circuit with a source of rapidly alternating or reversed currents of an electro-magnetic self-inductive reaction device or its described equivalent, normally out of action, and having a definite or determinate counter electromotive force capacity, adapted or adjusted, as described, to permit it, when substituted for a lamp or other device to oppose or check the passage of the alternating or reversed currents to a degree corresponding to the opposing effects arising from the electric resistance in the translating device."

In my patent filed May 21st, 1884, which is for a system of distribution using a continuous line current commuted through primary coils in series for the generation of secondary currents feeding local lines of lamps which are in multiple arc or in parallel, I refer to Fig. 8, which is described in the specification as follows:—

"Fig. 8 is a diagram illustrating a means whereby lights may be cut out in such a manner as not to affect each other's brilliancy." Then, further, in the description of the said figure occurs the paragraph, "Ordinarily the removal of a light or lights or other apparatus connected with a secondary would demand the readjustment of the speed of the commutator or of the relations of the coils or core in order to avoid any undue flow of current to the remaining lamps. To obviate this a small reactive coil of low resistance wound upon an iron core, indicated at R, Fig. 8, may be employed and combined with a suitable electric switch, whereby upon the cutting out of a lamp the said coil may be made to take its place. I mean by 'reactive coil' a coil whose opposition to the passage of alternating currents through it is due simply to its counter electromotive force tendency, and not to its resistance. The coils R R of Fig. 8 are of this nature, and since the secondary currents are alternating in character the substitution of one for a light extinguished leaves the relation of the electromotive forces to the remaining lamps constant, so that they do not change their brilliancy."

Claim 4 of this patent bears directly upon this subject matter. It is—"In combination with an induction coil, a local line connected with its secondary and containing translating devices and reactive coils, having switches, whereby reactive coils may be substituted for lamps extinguished."

The remaining patent, namely that filed May 25th, 1884, I send merely as illustrating another use of the reactive coil on alternating current circuits.

The applicability of the reactive coil according to the method described in these patents and its efficiency as a lamp substitute, with the saving of energy on such circuits, was proved by practice with this arrangement in a variety of ways. The identity of the device, which I have termed a "reactive coil to the induction ring," as used by Messrs. Sharpe and Kent in its functions as a lamp substitute, needs no further proof than a mere inspection of the copies of the patents sent. In fact, I may here make the broad statement that I believe it to be

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true that with any arrangement of alternating current circuits involving a connection of incandescent lamps in series, or in parallel, or in series multiple, or in multiple series, or whether induction coils are used in series, or in multiple, or in multiple series, or in series multiple, the reactive coil substitute may be used wherever a lamp or lamps are extinguished, and a proper balance of the distribution of the current effected thereby, so that the remaining lamps are undisturbed in brilliancy, and that a corresponding saving of energy, within a few per cent., will take place in proportion to the number of lamps extinguished in the system.—Yours, &c., ELIHU THOMSON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On pages 35-36 (*Electrician*, May 20, 1887) there is a note "On the Regulation of Series-wound (? Series-working) Transformers," with several tables.

Table I. gives the resistance of the external circuit, also watts expended in the rings when the number of these is varied; and on working through the figures in this table these two columns appear to me to be incorrect.

The resistance of each lamp is 160ω, and that of each ring 1ω.

From these data and the further data that the virtual resistance of each ring is 160 watts so that the current is always ·625 ampere, I calculate the table thus:—

Lamps in Circuit.	Rings in Circuit.	Resistance of external circuit.	Watts expended.		Watts expended in same circuit by steady E.M.F. of 100 volts.
n.	*m.*		Lamps.	Rings.	
16	0	10	1,000	0	1,000
12	4	·253	750	1·66	3,930
8	8	·124	500	3·13	8,050
4	12	·0826	250	4·80	12,100
1	15	·0661	62·5	5·88	15,100
0	16	·062	0	6·25	16,000

Column III. is calculated by formula $\frac{lr}{l+r}$, where $l=\frac{160}{n}$ and $r=\frac{1}{m}$.

Column IV. is calculated by formula $W=C^2Rn$, where C = ·625 ampere and R is 160 watts for each lamp. $W=C^2Rm$ where C = ·625 and R = 1 for each ring.—Yours, &c.,

LL. B. A.

[We are obliged to our correspondent for having called our attention to the point in question. In reality, however, the discrepancy belongs to some of the figures *in the first two columns only*, which seem to have been accidentally misplaced when the published figures were abstracted from a more complete table which had been compiled by the writer of the article. Our correspondent queries the use of the term "Series-Wound Transformer," but there seems to be no reason why the analogy of the terms in common use to describe the field-windings of dynamos should not be followed in this case.—ED. *E.*]

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We noticed lately in your pages that in estimating for some electric lighting electrical engineers were so hopelessly at variance that those who received their estimates decided to go back to gas. We have just heard to-day of a parallel case here in the north. A committee who had charge of lighting arrangements deemed it unwise to adopt a light about which so little was known, even by those who made a business of supplying it. As one of the competing parties we of course are of opinion that our estimate as to the number of lights, their distribution, and their cost, is right, and that we suffer because other competitors have erred; but the trouble is that the other competitors all probably hold a similar opinion as regards their own proposals.

What ought to be done? Architects and others in determining the number of gas jets to be fitted in a building are for the most part guided by experience and rule of thumb. But the electric light is more unfamiliar, and very vague ideas are abroad as to the area which a glow or an arc lamp can illuminate. It would be well to have a normal unit standard which might be used by engineers, and understood by architects, say so many cubic feet per candle-power, or a brightness over floor, or roof, or work tables of a standard candle at a fixed distance. Such units are used daily by experienced lighting engineers. What is wanted is that those units should be placed before architects and mill owners in a form readily comparable with their past experience, so that in asking for estimates they may be able to give a common basis to go upon. But the amount of light to be provided is only one thing among many on which opinions may differ. Perhaps the safest plan in most cases is to entrust the drawing up of a scheme and specification to a competent consulting electrician, who is, or ought to be, without direct or indirect pecuniary interest in any special form of apparatus. This would ensure a good and reliable plan and workmanship, although not necessarily the very best, for it fails to enlist the experience and ideas of those daily engaged in carrying out practical work. Whatever method is adopted, security is, after all, only to be obtained by the buyer personally knowing the men he deals with. If a man whose skill and care and honesty can be relied upon is not to be found, there is nothing for it but to submit to all the dangers and defects of estimating, and give the work into the hands of the people who have chosen to put in the cheapest material or undercalculated the necessary outlay.

We simply wish, however, to elicit opinion on this large subject, not to formally and fully discuss it.

Before ending we would like to select and give one example of the uselessness of giving away any ideas while still uncertain of being entrusted with the work at all. In April, 1886, we wrote (through the general manager) to the directors of the N.B. Railway Company, Edinburgh, suggesting several ways of lighting the trains or tunnels of their new underground line at Glasgow. After giving approximate prices of various methods of constant and intermittent tunnel lighting, we proceeded to schemes for train lighting. The first method being "each train complete in itself"; the second, "current derived from fixed engine and dynamo;" "carriages to be fitted up with separate wires, lanterns, connectors, &c., at a cost of, say, £4 per carriage;" then a named sum of further expenditure "would provide all appliances save a small engine and boiler (which, in our other proposals, was to be provided by the railway company, who already had sets of these which might be available), necessary for the automatic lighting up of these lamps when the train entered a tunnel and extinguishing them when the train emerged." Our third method was to use the ordinary compressed gas for train lighting, but arranged so that the guard could electrically light or extinguish instantaneously the whole train, and so on.

This "second method" was at that time a perfectly new suggestion for train lighting, and although non-technically described, was yet sufficient to have enabled any intelligent electrical workman, acquainted with the usual methods of transmitting electricity from fixed conductors to moving carriages, to carry out the work with more or less skill in mechanical detail. On May 17th of same year Mr. Carswell, a gentleman connected with the North British Railway Company's offices in Edinburgh, patented an almost identical system, and it has been adopted by that company, and the work carried out without our being asked to quote for those parts of the material of which we are manufacturers.—Yours, &c., ANDERSON AND MUNRO.

136, Bothwell-street, Glasgow.

THE LIGHTING OF TURIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Pickering has called in question the correctness of the information contained in the note you published in regard to the failure of the Gaulard and Gibbs system in Turin. The following extract, published independently by the Italian journal *L'Elettricita* (a copy of which I herewith forward), not only confirms the correctness of the original note, but gives additional information that may be of interest and furnish a clue to the actual cause of the failure:—

"The Gaulard transformers adopted by Messrs. Bellani

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Brothers, contractors for the electric lighting of a part of Turin, did not give the results that were expected in the public service.

"For the illumination of private parties, the contractors, instead of Gaulard transformers, installed the dynamos and transformers of Messrs. Zipernowsky and Déri.

"We have been informed that a large number of Gaulard transformers were found burned out and unfit for use, and Messrs. Bellani have decided to discontinue their employment for the public lighting. At the present moment the public service is secured by the Zipernowski-Déri system.

"The public illumination includes 80 incandescent lamps of 50 candle-power, and 3 arc lamps, all of which are run by the Zipernowsky-Déri system."

In addition, I have in my possession the results of tests made upon the Siemens cables before, during, and after the trials, which show that the failure must be ascribed to some other cause, considering, too, the fact that both systems used alternate currents, not differing greatly in electromotive force.

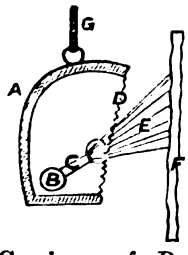
As the note in question contained no reference as to cause, but confined itself to facts, which Mr. Pickering has not shown to be untrue, I think he has no grounds for complaint.—Yours, &c.,

J. W. LIEB.

THE FIRE AT THE OPERA COMIQUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was an eye witness of the catastrophe that occurred last night at the "Theâtre National de l'Opera Comique." It was about the end of the first act in "Mignon" when one of the gas jets in the cross light sputtered owing to a shock which that particular cross light received, due to some stage manipulation. The moment the light reached a sort of net decoration, in close proximity to the cross light, the net caught fire like ignited gun cotton. The decorations being so near the gas lights are always very warm and dry, so that they burn like tinder when lighted. The following is a little sketch in cross section, which shows how the fire originated:—



A is the iron frame of the cross light suspended by ropes G. B is the main gas tube, which has at regular intervals jets C, D is a sort of wire gauze, and F shows the decoration in front of the cross lights, E represents the sputter which ignited the decoration F, and caused the loss of so many lives and damage to property.

In a few moments the fire spread over the whole stage, and to-day the Opera Comique of Paris comes within the long list of such calamities which have occurred within the last few years, and reminds one of the Ring Theatre, Stadt Theatre in Vienna, the Arad Theatre and Szegedin Theatre in Hungary, the Nice Theatre, Rouen Theatre in France, and Alhambra in London. These are only a few of the principal ravages that our contemporary the gas light has been the cause of.

Had not the Cie. Continentale Edison been hindered from commencing their work last September, the disaster of yesterday would not have happened; but instead of receiving their contract last year they only received it a few weeks ago. They have been actively pushing their installations, and expected to commence electric lighting in July.—Yours, &c.,

FRANCIS JEHL.

25, Rue Jacob, Paris, May 26th, 1887.

SECONDARY BATTERY QUESTIONS IN BELGIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR, [illegible] statement which I have made as to the use of miniu[illegible] the construction of accumulators rests upon the auth[illegible] of the late Comte Du Moncel. When Du Moncel w[illegible] following paragraph there can be no doubt that his i[illegible]ion came from a reliable source. He says:—

"[illegible]t[illegible] avait bien pensé, *des ses premières recherches*, à abréger [illegible]e la formation, en déposant sur les lames de plomb [illegible] minium et en réduisant cette couche par le courant [illegible] . . . . mais l'adhérence de celle-ci était mauvaise et la couche déposée s'écaillait et finis sait par disparaître.

"Quand en 1881, on pensa à employer les accumulateurs pour l'eclairage électrique et les moteurs, M. Faure *reprit l'idée* de l'application de la couch de minium sur les lames de plomb, et pour maintenir l'adhérence, il enveloppa les lames recouvertes de minium dans des sacs de feutre." "Eclairage Electrique," Du Moncel, 1883, Vol. I., pages 56 and 57.

The problem which remained to be solved after M. Planté was merely to discover a satisfactory method of attaching the minium to the lead plate, and this problem, it is very certain, every one has a right to solve in his own fashion.—Yours, &c.,

YOUR CORRESPONDENT.

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XL.

BY OLIVER HEAVISIDE.

(Continued from page 51.)

Preliminary to Investigations concerning Long-distance Telephony and Connected Matters.

Although there is more to be said on the subject of induction balances, I put the matter on the shelf now, on account of the pressure of a load of matter that has come back to me under rather curious circumstances. In the present article I shall take a brief survey of the question of long-distance telephony and its prospects, and of signalling in general. In a sense, it is an account of some of the investigations to follow.

Sir W. Thomson's theory of the submarine cable is a splendid thing. His paper on the subject marks a distinct step in the development of electrical theory. Mr. Preece is much to be congratulated upon having assisted at the experiments upon which (so he tells us) Sir W. Thomson based his theory; he should therefore have an unusually complete knowledge of it. But the theory of the eminent scientist does not resemble that of the eminent scienticulist, save remotely.

But all telegraph circuits are not submarine cables, for one thing; and, even if they were, they would behave very differently according to the way they were worked, and especially as regards the rapidity with which electrical waves were sent into them. It is, I believe, a generally admitted fact that the laws of Nature are immutable, and everywhere the same. A consequence of this fact, if it be granted, is that all circuits whatsoever always behave in exactly the same manner. This conclusion, which is perfectly correct when suitably interpreted, appears to contradict a former statement; but further examination will show that they may be reconciled. The mistake made by Mr. Preece was in arguing from the particular to the general. If we wish to be accurate, we must go the other way to work, and branch out from the general to the particular. It is true, to answer a possible objection, that the want of omniscience prevents the literal carrying out of this process; we shall never know the most general theory of anything in Nature; but we may at least take the general theory so far as it is known, and work with that, finding out in special cases whether a more limited theory will not be sufficient, and keeping within bounds accordingly. In any case, the boundaries of the general theory are not unlimited themselves, as our knowledge of Nature only extends through a limited part of a much greater possible range.

Now a telegraph circuit, when reduced to its simplest elements, ignoring all interferences, and some corrections due to the diffusion of current in the wires in time, still has no less than four electrical constants, which may be most conveniently reckoned per unit length of circuit—viz., its resistance, inductance, permittance, or electrostatic capacity, and leakage conductance. These connect together the two electric variables, the potential difference and the current, in a certain way, so as to constitute a complete dynamical system, which is, be it remembered, not the real but a simpler one, copying the essential features of the real. The potential difference and the permittance settle the electric field, the current and the inductance settle the magnetic field, the current and resistance settle the dissipation of energy in, and the leakage conductance and

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potential difference that without the wires. Now, according to the relative values of these four constants it is conceivable, even, I should think, by the eminent scienticulist, that the results of the theory, taking all these things into account, will, under different circumstances, take different forms. The greater includes the lesser, but the lesser does *not* include the *greater*.

In the case of an Atlantic cable it is only possible (at present) to get a small number of waves through per second, because, first, the attenuation is so great, and next it increases so fast with the frequency, thus leading to a most prodigious distortion in the shape of irregular waves as they travel along. Of course we may *send* as many waves as we please per second, but they will not be utilisable at the distant end. This distortion is a rather important matter. Mere attenuation, if not carried too far, would not do any harm. Now the distortion and the attenuation, though different things, are intimately connected. The more rapidly the attenuation varies with the frequency, the greater is the distortion of arbitrary waves; and if the attenuation could be the same for all frequencies, there would be no distortion. This can be realised, very nearly, as will appear later.

Now when there are only a very few waves per second, the influence of inertia in altering the shape of received signals becomes small, and this is why the cable theory of Sir W. Thomson, which wholly ignores inertia, works as a substituted approximate theory. But suppose we shorten the cable continuously, and at the same time raise the frequency. Inertia becomes more and more important; the theory which ignores it will not suffice; and carrying this further, we at length arrive at a state of things in which the old cable theory gives results which have no resemblance whatever to the real. This is *usually* the case in telephony, as I have before proved. It is always partly the case, viz., for the very high frequencies, and it may be true, and practically is sometimes down to the low frequencies also. I have shown that the attenuation tends to *constancy*, as the frequency is raised, except in so far as the resistance of the wire increases, and that at the same time the speed of the waves tends to approximate to the speed of light, or to a speed of the same order of magnitude, which is the only speed which can, I think, be said, even in a restricted sense, to be the "speed of electricity." But if the dielectric be solid, there must be some uncertainty about what this speed is, for obvious reasons, with very high frequencies. The speed of the current is *never* proportional to the square of the length of the line. I swear it.

Within the limits of approximately constant attenuation the distortion is small. This is what is wanted in telephony, to be be good. Lowering the resistance is perhaps the most important thing of all. Other means I will later mention. What the limiting distance of long-distance telephony may be who can tell? We must find out by trial. We know that human speech admits of an extraordinary amount of distortion (never mind the attenuation) before it becomes quite unrecognisable. The "perfect articulation," "even different voices could be distinguished," &c., &c., mean really a large amount of distortion, of which little may be due to the circuit. There is the transmitter, the receiver, and several transformations between the speaker and the listener, besides the telegraph line. What additional amount of distortion is permissible clearly must depend upon what is already existent due to other causes. Even if that be fixed I see no legitimate way of fixing its amount by theoretical principles; the matter is too involved, and includes too many unknown data, including "personal equation." But this is certain, in my opinion—that good telephony is possible through a circuit whose electrostatic time-constant, the product of the total resistance into the total permittance, is several times as big as the recent estimate of Mr. W. H. Preece, and I shall give my reasons for this conclusion.

Increasing the inductance is another way of improving things. Hang your wires wider apart. The longer the circuit, the wider apart they should be; besides this, they may be advantageously raised higher. You can then telephone further, with similar attenuation and distortion. There is a critical value of the inductance for minimum attenuation ratio. It is from $L = Rl/2v$ to $L = Rl/v$, according to circumstances to be later explained; L being the inductance and R the resistance per unit length, l the length, and v the speed of waves which are not, or are only slightly dissipated, which is $(LS)^{-\frac{1}{2}}$ if S be the permittance per unit length. The resulting attenuation may be an enlargement, as I have before explained, due to to-and-fro reflections. This is to be avoided. I shall explain its laws, and how to prevent it. By this method, carrying it out to an impracticable extent, however, we could make the amplitude of sinusoidal currents received at the distant end of an Atlantic cable greater than the greatest possible steady current from the same impressed force, an unbelievable result. And, without altering the permittance or the resistance, we could make the distortion quite small.

There is some experimental evidence in favour of increasing the inductance (apart from lessening the permittance); though, owing to want of sufficient information, I do not wish to magnify its importance. I refer to the statement that excellent results have been obtained in long-distance telephony with copper-covered steel wires. Here the copper covering practically decides the greatest resistance of the wire; what current penetrates into the steel lowers the resistance and increases the inductance. Clearly, we should magnify this effect, and electrically speaking, it would seem that a bundle of soft-iron wires with a covering of copper is the thing, as this will allow the current to more readily penetrate, lower the resistance the most, and increase the inductance the most. But it is too complex a matter for hasty decision. We also see that the iron sheathing of a cable may be beneficial.

When we have little distortion, we get into the regions of radiation. The dielectric should be the central object of attention, the wires subsidiary, determining the rate of attenuation. The waves are waves of light, in all save wave length, which is great, and gradual attenuation as they travel, by dissipation of energy in the wires. There is the electric disturbance and the magnetic disturbance keeping time with it, and perpendicular to it, and both perpendicular to the transfer of energy, which is parallel to the wire very nearly. A tube of energy-current we may regard as a ray of light (dark, of course). (It is to such *long* waves that I attribute the magnetic disturbances that come from the sun occasionally, and simultaneously show themselves all over the world; arising from violent motions of large quantities of matter, giving shocks to the ether, and causing the passage from the sun of waves of enormous length. On such a wave passing the earth there are immediately induced currents in the sea, earth's crust, telegraph lines, &c.) But to return to the circuit. The attenuation ratio per unit length is represented by $\epsilon^{-R/2Lv}$, this being the ratio of the transmitted to the original intensity of the wave. This is when the insulation is perfect. These waves are subject to reflection, refraction, absorption, &c., according to laws I shall give. Of these the simplest cases are reflection by short-circuiting, when the potential difference is reversed by reflection, but not the current, and in the act of reflection the former is annulled, the latter doubled. Also reflection by insulation, when it is the current that is reversed, and potential difference unchanged; or, in the act of reflection, the first cancelled, the second doubled. But there are many other cases I have investigated.

I have also examined leakage. This is an old subject with me. An Atlantic cable is worked under the worst conditions (electrical) possible with high insulation; there is the greatest possible distortion. One megohm per mile or less instead of hundreds or thousands would vastly accelerate signalling. The attenuation factor is now $\epsilon^{-R/2Lv}\,\epsilon^{-K/2Sv}$ if K be the leakage conductance, and S the permittance per unit length. The attenuation is increased, but the distortion is reduced. This has led me to a theoretically perfect arrangement. Make $R/L = K/S$, and the distortion is annihilated (save corrections for increased resistances, &c.). The solution is so simple that I may as well give it now. Let V and C be the potential difference and current at distance x subject to

$$-\frac{dV}{dx} = RC + L\dot{C}, \qquad -\frac{dC}{dx} = KV + S\dot{V},$$

then, with equality of time-constants as described, the solution consists of two oppositely travelling trains

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of which we need only write one; thus,

$$V = f(x - vt)\,\epsilon^{-Rt/L},$$

where $f(x)$ is the state when $t = 0$. The current is $C = V/Lv$. The energy is half electric, half magnetic; the dissipation is half in the wire, half outside. Change the sign of v in a negative wave. There is a perfect correspondence of properties, when this unique state of things is not satisfied between V solutions with $K = 0$, and C solutions with $R = 0$. This perfect system would require very great leakage in an Atlantic cable, and cause too much attenuation; but this perfect state may be aimed at, and partly reached. Are there really any hopes for Atlantic telegraphy? Without any desire to be over sanguine I think we may expect great advances in the future. Thus, without reducing the resistance or reducing the permittance (obvious ways of increasing speed), increase the leakage as far as is consistent with other things, and increase the inductance greatly. One way is with my non-conducting iron, which I have referred to more than once, an insulator impregnated with plenty of iron dust. Use this to cover the conductor. It will raise the inductance greatly, and so greatly diminish the attenuation, whilst the insulation resistance will be lowered, somewhat increasing the attenuation, but assisting to diminish the distortion, which the increased inductance does. The permittance change must also be allowed for. But I shall show that we can have practical approximations to almost negligible distortion in telephony, and that it is the reduction of R/L that is most important.

I have also examined the question of apparatus. We must stop the reflection, if possible, to prevent interference. In the perfect system this is also quite easy. The receiver must have resistance Lv and zero inductance. All waves arriving are then wholly absorbed. Similarly, to make the transmitted waves agree with the impressed force, Lv should be the resistance there (or else zero). Another remarkable property is that if the receiving coil be fixed in size and shape, whilst its resistance varies, then this same Lv is the resistance that makes the magnetic force of the coil a maximum. We cannot imagine anything more perfect. No distortion, and maximum effect. I shall show that these things may be fairly approximated to in telephony. It should be understood that in the perfect system we have nothing to do with what the frequency may be, whilst in telephony it is the high frequency that allows us to approximate to the ideal state.

Then there is the matter of bridges, and the nature of the reflected, transmitted and absorbed waves. The phenomena formally resemble those due to the insertion of resistance in the main circuit, except that the potential-difference and the current change places. Thus if R_1 be an inserted resistance, when there is no leakage and no resistance in the line $(1 + R_1/2Lv)^{-1}$ is the ratio of transmitted to incident wave. Now let there be no resistance inserted, but a bridge of conductance K_1; then the substitution of K_1 for R_1, and S for L gives us the corresponding formula. In the first case the reflected current is reversed, in the second case it is the potential difference of the reflected wave that is reversed. Now let there be both a resistance inserted and a conducting bridge, and choose $R_1/L = K_1/S$; then the reflected wave is abolished. Part of the original wave is absorbed in the bridge, and the rest is transmitted unchanged. This explains the perfect system above described.

I have also examined the changes made when the state is not perfect. The result is that a wave throws out a long slender tail behind it; and whilst the nucleus goes forward at speed v, the tail goes backwards at this speed. In time, if the line be long enough, the nucleus, which changes shape as it progresses, diminishes so as to come to be a part of the tail itself. It is then all tail. I will give the equation of the nucleus and tail. It is the mixing up of these tails that causes arbitrary waves to be distorted as they travel from beginning to end of the line. (But I have, in the above, usually referred to distortion as the change in the shape of the curve of current at a single spot.) There is residual reflection due to self-induction of receiver, even when the resistance is of the proper amount. The effect of diffusion in the wires is to make a wave with an abrupt front, which would continue abrupt, to have a curved front, and thus mitigate that perfection which only exists on paper. I shall also describe graphical methods of following the progress of waves, and of calculating arrival curves of various kinds, the submarine cable and oscillatory, approximate only, but very easy to follow. Other matters, perhaps more practical, but certainly duller, will find their place, if space allow.

(To be continued.)

MEASUREMENT OF THE DIFFERENCE OF POTENTIAL BETWEEN TWO METALS IN CONTACT.*

BY M. H. PELLAT.

We know that electroscopical measurements are unable to furnish us with the real difference of potential of two metals in contact, as they are complicated by differences of potential between the metals and the surrounding medium. Neither, on the other hand, does the phenomenon of Peltier (as was at one time believed) permit us to make such measurements. This has been shown by the author (*Journal de Physique*, Vol. IX., p. 122). In the absence of all positive data as to this quantity opinions are divided, certain physicists believing, with Volta, that its value is of the same order as that of the E.M.F. of the voltaic cell, others holding, with Maxwell, that it has a much smaller value of the order of thermo-electric E.M.F.'s.

I shall now describe an experiment which offers an exact solution of the problem in a particular case, and demonstrates the correctness of Volta's views.

We must first recollect that the surface of contact of two conductors may be compared to a condenser, the conductor at the higher potential being charged with a layer of positive electricity, opposed to which we have an equal quantity of negative electricity upon the surface of the conductor of lower potential, the value of each of these layers vanishing when the potentials are equalised.

Consider now the following apparatus:—Two vessels in communication, and full of mercury; the one, A, is wide, the other, B, is formed by a narrow tube—almost a capillary tube. A third vessel, C, of considerable width also contains mercury. In B and in C the mercury is covered with acidulated water, and these two vessels communicate by means of a siphon filled with the same liquid. Next two platinum wires connect respectively the mercury in C and that in B with the two terminals of a galvanometer.† Under these conditions, if we cause to vary, even very slightly, the extent of the surface of contact of the mercury in B with the acidulated water the galvanometer shows a current, of which the direction depends upon the *sign* of the variation. This phenomenon was discovered by M. Lippmann, and the explanation readily follows from considering the double electric layer on the surfaces in contact; the circuit being closed, the difference of potential between the accidulated water and the mercury B is constant. If, then, we vary the extent of the surface of contact the effect is the same as if we varied the dimensions of the plates of a condenser connected with a source of E.M.F. which maintained their difference of potential constant; the variation of surface necessitates, therefore, a current of charge or discharge. The direction of the current in this case shows that the mercury is at a higher potential than the acidulated water.

But I have considered that we might annul these currents, or even reverse their direction by introducing into the circuit an E.M.F. which should polarise in the required sense the mercury in the small tube B, without sensibly polarising the mercury in the large vessel C. For this purpose I have made use of an E.M.F. of known and variable value, and I find that when $e = 0{\cdot}97$ volt a variation in the extent of contact surface no longer produces a current. Under these conditions the double electric layer between the mercury B and the acidulated water is cancelled; that is to say these two liquids are now at the same potential. It follows that the difference of potential between the mercury C in the wide vessel (non-polarised) and the acidulated water has an absolute value of 0·97 volt. The number thus found is in accordance with that deduced by M. Lippmann from the E.M.F., which makes the capillary constant for mercury a maximum.

I have then proceeded to replace the pure mercury in all the tubes with a zinc amalgam, and I find that *the normal difference of potential between amalgamated zinc and acidulated water is nearly zero*, actually 0·02 volt in the same sense as for mercury.

Next I proceeded to make a cell, having for electrodes mercury and liquid amalgam of zinc separated by acidulated water, using as electrodes two platinum wires. The E.M.F. of this cell was 1·44 volt. But representing in general by X | Y the excess of potential of conductor Y over conductor X at the surface of contact, and

* Note presented to the French Academy of Sciences by M. Lippmann.

† [The connection with B is apparently made through the wide vessel A this being the only purpose for which A is required.—*Translator.*]

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designating by P, M, A, L the platinum, mercury, amalgam, and acidulated water respectively, we have the equation of identity

$$E = P \mid A + A \mid L + L \mid M + M \mid P,$$

and as $E = 1{\cdot}44$, $L \mid M = 0{\cdot}97$, $A \mid L = -0{\cdot}02$,

we see that $P \mid A - P \mid M = 0.49$ volt.

Thus the true difference of potential of the platinum and the zinc amalgam at the contact P | A must be greater than 0·49 volt by the quantity for the platinum and mercury, P | M. For the rest, by Volta's law, we have

$$P \mid A - P \mid M = M \mid A,$$

that is to say, that the mercury shows an excess of potential over the amalgam in contact with it of 0·49 volt.

Thus, in this cell, the difference of potential between the liquid and the metal attacked is very nearly *nil*, whilst it is relatively large either between the liquid and the metal not attacked or between the two metals.

TRANSMISSION OF POWER AT THE MANCHESTER EXHIBITION.

Although much attention has been given to the transmission of power by electricity, and its application to electrical tramways and railways and the utilisation of water-power at a distance, the distribution of power by this means in workshops, factories, shipyards, and similar places has received comparatively little attention. At the same time there is no doubt that there is in this direction a very wide field for the use of electrical motors. This is especially so in those works where for various reasons the principal machines and tools are not driven from one common system of shafting, but have each an independent engine. Such is the case in printing works, where each printing machine is driven by its own engines; also in paper mills, in rolling mills, and in many shipbuilding yards, and other large engineering shops, where the heavier tools are necessarily distributed over a large area, and where it is important to have complete control over each individual tool. It is with the special intention of showing the applicability of electrical driving in these cases and its advantages that Messrs. Mather and Platt have designed their exhibit at the Manchester Exhibition. As a typical case, and one in which the conditions to be met are most stringent, they have chosen one of their ten-colour calico printing machines, for printing calico with ten colours simultaneously. If electrical driving can be proved to be advantageous and economical for complex machinery of this class, where a slow speed under the most perfect control and at the same time high efficiency are essential, there is no doubt about its applicability in other cases where the conditions are less exacting.

A large printing machine, similar to the one exhibited, would be driven under ordinary circumstances by a double cylinder diagonal engine, with cylinder 10in. diameter, 12in. stroke, running at about 180 revolutions per minute. The star wheel of the printing machine when printing at full speed runs at 12 or 13 revolutions only, it is therefore necessary to reduce the speed by gearing. But where a dynamo motor is used in place of the steam engine, the speed of the motor must be much higher in order to obtain good efficiency without unduly increasing the size and cost of the motor. The motor employed at the exhibition runs at 700 revolutions; hence the speed must be reduced in the ratio of 56·1. This is accomplished by a combination of belt and spur gearing. The dynamo shaft is fitted with a pulley 16½in. diameter, driving by means of a short belt on to a pulley 54in. diameter. In order to increase the grip of the small driving pulley on the belt Messrs. Mather and Platt's system of a loose "jockey" pulley is employed. The jockey pulley runs on a stud fixed on an arm projecting from the dynamo bed, and bears against the slack side of the belt. By an arrangement of worm and wheel the arm can be raised or lowered, moving the loose pulley with it, and consequently increasing or diminishing the angle at which the belt is bent over it. By this means the surface of contact between the belt and the driving pulley can be increased, and the slack of the belt taken up, thus at the same time giving an adhesion equal to that of a long belt, and providing means for taking up the slack as the belt stretches. The speed is further diminished by a train of two internal spur wheels and pinions. The combination gives a most effective drive, perfectly noiseless, occupying no more space than the gear for reducing the speed of a steam engine, and under perfect control.

The printing machine is of Messrs. Mather and Platt's latest design for printing cloth up to 34in. wide, with from one to ten colours simultaneously, at a speed of 30 yards per minute. The machine is fitted with transverse motion for the doctors, long rollers, and steam drying. To work it at full speed from 15 to 20 horse-power is required. In order to set the pattern it is essential that the speed of the machine should be so under control that it can be made to "creep" round, and can be stopped in a fraction of a revolution, so as to enable the printer to see that the rollers, each printing one colour, are properly adjusted relatively to one another. With a steam engine this is effected by a throttle valve on the steam inlet, the valve spindle being fixed conveniently accessible to the printing. But a steam engine must have a fly-wheel, and the valves cannot be instantaneously closed, so that the machine cannot be stopped as quickly as might be desired. A dynamo motor, on the other hand, having no dead points, requires no fly-wheel, and the current can be instantaneously shut off, and consequently the machine brought to a stand more rapidly than is possible with steam engine driving. The speed is regulated by a switch-board placed at one side of the machine at the printer's right hand, arranged to insert resistance in the circuit, and so lowering the speed of the motor to any desired extent. The whole floor space covered by the motor, driving gear, and resistance, is somewhat less than that which a steam engine would take, a point of much importance in print works.

The current is conveyed to the motor from a generating dynamo by an insulated copper cable carried under the floor of the Exhibition buildings. The generating dynamo is fixed in the dynamo house immediately adjacent to Messrs. Mather and Platt's pair of vertical engines and dynamos for lighting the fine art section. The distance from generator to motor is forty-five yards, but this might be greatly increased with very slight increase in the proportion of power lost in transmissions. The generating dynamo is also of the Manchester type, and is a similar machine to the motor, capable of generating 25 to 30 electrical horse-power at a speed of 950 revolutions per minute. It is driven by a double-cylinder diagonal engine with cylinders 8in. diameter, 10in. stroke, and running at 180 revolutions per minute, with a short belt driving on the same principle as that used with the motor. Although a separate engine and generating dynamo are provided this is not necessary, and the current could be obtained from any dynamo of sufficient power used for lighting or for working other motors.

Arrangements have been made for connecting the motor cables to any of the four dynamos working the incandescent lamps in the art galleries.

The whole loss in conversion from mechanical to electrical power in transmitting the electrical power and reconverting into mechanical power does not exceed 25 per cent. This is far more than compensated for by the fact that the engine driving the generating dynamo can be worked under the most economical conditions, which is impossible with an engine driving direct.

No better illustration of this could be afforded than the fact that actually a smaller engine is employed for driving the generating dynamo than would have been employed had the printing machine been driven direct.

In a large print works, where there are a considerable number of independent machines, the advantage will be still more conspicuous. For in place of a separate small engine to each machine, working necessarily with low steam pressure, often with considerable back pressure, and generating under conditions where high efficiency is impossible, a single high-class engine can be used working under the most favourable conditions with high pressure steam, high expansion proper automatic cut-off valves giving the highest efficiency. This engine would be employed to drive one or more generating dynamos, which might also be employed for lighting purposes, and from these cables would be taken to each independent machine worked by its own motor.

Such a system has, moreover, the advantage of avoiding the necessity of steam and exhaust pipes and drain pipes for the engines running throughout the building—a point of considerable importance when the operations carried on require great cleanliness.

Briefly, the advantages of the system of electrical motors for the distribution of power may be summarised:—1. Greater economy in consumption of fuel. 2. More perfect control over each individual machine. 3. Greater cleanliness. 4. The availability of the plant used for the distribution of power for electric lighting and other purposes.

ELECTRICITY ON THE "DOGALI."

The Italian cruiser "Dogali," at present the fastest sea-going war vessel in the world, which has been built and armed by Messrs. Sir W. G. Armstrong, Mitchell and Co., of Elswick, has been fitted by her builders with a very complete electric light installation. In all some 150 16 candle-power Swan incandescent lamps are employed for the internal lighting of the vessel, and there are also two search light projectors, supplied by Messrs. R. E. Crompton and Co., of Chelmsford, each taking 125 amperes, with an E.M.F. at the dynamo of 80 volts, and giving a light of about 25,000 candle-power.

The electric engine room, which is situated over the main engine rooms, contains three Parsons electric generators, supplied by Messrs. Clarke, Chapman, Parsons and Co., of Gateshead-on-Tyne. Each generator consists of a Parsons patent steam turbine, driving a direct shunt-wound Parsons dynamo machine, the two being on a single bed plate, and supplies a maximum current of 125 amperes

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with an E.M.F. of 80 volts. The generators run at the very high speed of 9,000 revolutions per minute (150 per second), but, notwithstanding this, there is no undue beating of the bearings, and as there are no reciprocating parts, and everything is absolutely balanced, there is very little wear and little or nothing to get out of order. Since the lubrication is forced and entirely automatic, the oil circulating continuously through the bearings, the generators will run without attention for long intervals.

As mentioned above, the dynamos are shunt-wound, but each is fitted with an electro-pneumatic governor, which controls the speed of the engine so as to maintain a perfectly constant E.M.F. The total weight of each complete generator, including engine, dynamo, governor, bed-plate, &c., is only 8cwt., and the over-all dimensions are 6ft. 3in. long, 2ft. 3in. high, and 12in. wide, this extraordinarily small weight and bulk in relation to power (10,000 watts), being, of course, largely due to the high speed attained. One of the generators is capable of running all the incandescent lamps used for the internal illumination of the vessel, while the other two are employed to work the two search lights, each of which is supplied with current through a wire resistance of ·2 ohm in order to ensure steadiness in the arc.

By means of a switch-board in the electric engine room any one dynamo can be connected to any combination of one or more circuits; but while this is effected the dynamos are always quite distinct from one another, it being impossible for there to be any connection between them through either the positive or negative conductors. Thus any mishap to the insulation of one dynamo or circuit cannot in any way affect the others. The switch-board was specially designed to meet these requirements by Mr. A. A. Campbell Swinton, until recently electrical engineer to Messrs. Sir W. G. Armstrong, Mitchell and Co., under whose superintendence the whole of the installation has been carried out.

The vessel is also fitted with electrical arrangements for firing the guns from the conning tower or the bridge, it being possible to fire the guns either one at a time or in a simultaneous volley. There is also electrical communication between the torpedo director stations on the upper deck and the discharging tubes beneath, so that the officer at the director can launch a torpedo with his own hand, though he is some distance removed from the discharging mechanism.

Both for the electric light and firing circuits the ship is wired upon the system introduced for ship lighting by Mr. Swinton, according to which the usual wood casing is dispensed with altogether, all the wires being lead sheathed and the joints covered and rendered watertight by means of cast lead boxes filled in with cement. This arrangement has a very neat appearance in the cabins, engine rooms, and other portions of the vessel, as the wires can readily be bent to suit the exigencies of their position, and when painted are scarcely noticeable.

The "Dogali" is the fourth large vessel which Messrs. Armstrong have wired on this system, and there are four other cruisers besides a torpedo boat in progress.

The lead sheathed wire and cable has been supplied by the India-rubber Company, Silvertown.

MODES OF MEASURING THE CO-EFFICIENTS OF SELF AND MUTUAL INDUCTION.*

By Profs. W. E. Ayrton, F.R.S. and John Perry, F.R.S., Members.

(*Concluded from page 60.*)

Capacity.

By following the train of reasoning given in this paper it is easy to show that if, instead of placing a coil with self-induction in one of the arms of the bridge, the arm be shunted with a condenser there will be an apparent diminution of the resistance of that arm, since a resistance shunted with a condenser acts like a *negative* self-induction, and that *this apparent diminution divided by the product of the square of the actual resistance of the arm into the reading of the scale of the secohmmeter corresponding with the speed at which balance is obtained gives the capacity of the condenser absolutely in farads.* This formula is far simpler than the one given by Clerk-Maxwell for the capacity of a condenser determined by placing the condenser on one of the arms of the bridge and rapidly alternating the connections of the condenser with the bridge.

APPENDIX I.

Other Methods of Measuring a Coefficient of Self-Induction.

As mentioned in the early part of this paper, a number of *cumulative* methods were tried by Mr. Sumpner for measuring self-induction, and the appropriate formulæ worked out by him in each case. The following short account of them is given as evidence of our desire not to publish the secohmmeter method until we had satisfied ourselves that there was not a better one. Indeed, that is one of the reasons why the publication has been delayed so long after the instrument has been in practical use.

* Paper read before the Society of Telegraph-Engineers and Electricians on April 28th, 1887.

Connect the coil of resistance, r ohms, and a coefficient of self-induction, L secohms, with the terminals of a condenser of F farads capacity, Fig. 8. By means of a reversing communicator, C, alternate the connections of the coil and condenser at the rate of N times per minute with the terminals of the circuit consisting of the battery of E.M.F. equals E volts and a galvanometer, the resistance of which, together with that of the battery is g ohms. The object of using the condenser is to prevent the self-induction of the coil producing sparks on reversing.

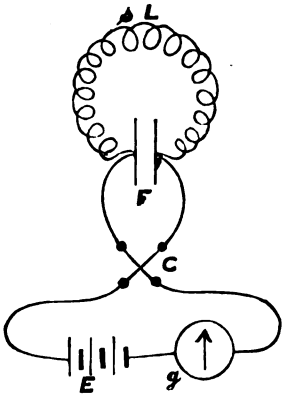

Fig. 8.

Let D_0 be the galvanometer deflection when the commutator is at rest, and D_1 when it is revolving, then it can be shown that

$$L = F s^2 + \frac{g+s}{2} \cdot \frac{D_0 - D_1}{N D_0} \text{ secohms},$$

if the reversals of currents in the coil be not too rapid for the currents to reach their steady value, and if the reversing commutator reverses instantaneously without short-circuiting. But the method, as it stands, seems impracticable, as it is impossible to devise a commutator that will reverse without short-circuiting or producing a discontinuity for a certain time between every reversal.

If there be short-circuiting, then the condenser may be dispensed with, and if the time of short-circuiting be small compared with $\frac{L}{s}$, and if g be not small compared with s, it can be shown that

$$L = \frac{g+s}{2N}\left(\frac{D_0 - D_1}{D_0} + m\right),$$

where m is a very small constant depending on the values of g and r and on the proportion of periodic time of commutation during which the short circuit lasts. m may be eliminated by taking two readings, D_1 and D_2 at different speeds, N_1 and N_2, and if the E.M.F. used when the commutator be revolving be n times as great as when the commutator is at rest, we have

$$L = \frac{g+s}{2D_0} \cdot \frac{D_2 - D_1}{N_2 - N_1} \frac{1}{n}.$$

This method of testing, although fairly simple, and possessing the great advantage of making the effects *cumulative*, is not nearly as sensitive as the following *zero cumulative* method, which is based on the same principle.

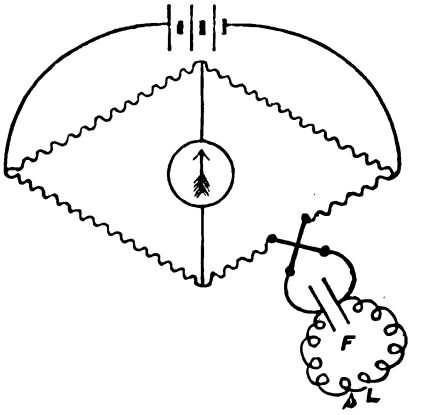

Fig. 9.

The coil with self-induction condenser and commutator are put in one of the arms of a Wheatstone bridge, as shown on Fig. 9, then with the same notation as before it can be shown if

(1st) The speed of reversal be not too great for the currents to reach the steady value,

(2nd) The commutator reverses instantaneously without short-circuiting,

that $$L = F s^2 + \frac{1}{1 + \frac{\sigma}{r_1}} \cdot \frac{T\sigma}{2},$$

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where σ is the apparent increase of resistance, r_s the resistance of s plus that of the network between the extremities of s supposing s removed, and T is the time of a reversal.

It is easy to arrange that $\frac{\sigma}{r_s}$ shall be negligible, and, unless F or s be large, Fs^2 can also be neglected, so that we obtain the very simple formula

$$L=\frac{T\sigma}{2},$$

a result that is independent of λ, the coefficient of self-induction of the galvanometer.

To satisfy condition 2 is extremely difficult, if not impossible, and therefore it is better to allow the commutator to introduce a short circuit between the reversals, in which case the condenser previously employed to prevent sparking at the reversals may be dispensed with.

As the complete investigations previously made on the use of the secohmmeter for the measurement of the coefficients of self and mutual induction have shown that self-induction of the galvanometer does not seriously affect the practical result, we will, for simplicity, in this investigation of the theory of the zero short-circuiting commutator test, neglect the self-induction of the galvanometer from the beginning. Consequently the current x through the galvanometer (Fig. 9) is given by the equation

$$A\,x+B'L\frac{dx}{dt}=Ep\sigma.$$

Now, if Q_1 be the quantity of electricity that flows through the galvanometer during the reversal, excluding the period when the commutator is short-circuited, and Q_2 the quantity that flows through during this period, and if T and τ be the times of a complete reversal and of a short circuit respectively, reckoned from the commencement of the short-circuiting,

$$A\,Q_1+B'L\left(x_T-x_\tau\right)=Eps\,(T-\tau);$$

also

$$Q_2=\frac{Ep(s+\sigma)}{A'}\tau,$$

where A' is the value of A when s is made equal to nought. If the time of short-circuiting be but a small portion of the whole time of a reversal, Q_2 will be but a small correction. And an examination of the value of A, given on page 19, will show that unless s be very large compared with $b+r$ or with $g+q$, putting s equal to nought will not much change the value of A; in other words, A' may be taken as equal to A. Hence we have

$$A\,(Q_1+Q_2)+B'L\left(x_T-x_\tau\right)=Ep\,(\sigma T+s\tau).$$

Now Q_1+Q_2 must equal nought for balance, and $\frac{\tau}{T}$ is a constant, l say for a given adjustment of a given commutator. Hence

$$B'L\left(x_\tau-x_T\right)=-EpT(\sigma+ls)\quad\ldots\quad(18)$$

If y_s be the *steady* value of the current in s, then taking into account the partial dying away of the current during the time of short circuit, τ, the current in s immediately after reversal will be

$$-y_s\,\epsilon^{-\frac{s\tau}{L}},$$

and if τ be small compared with $\frac{s}{L}$, this is equal to

$$-y\left(1-\frac{s}{L}\tau\right).$$

From equations (6) and (7), given above, we can deduce that

$$B'x+Ep=B''y,$$

where B' or B'' are functions of the resistances; therefore

$$\frac{B'x}{\tau}+Ep=-B''y_s\left(1-\frac{s}{L}\tau\right)$$

$$B'x_T+Ep=B''y_s$$

$$\therefore B'\left(x_\tau-x_T\right)=B''y_s\left(\frac{s}{L}\tau-2\right)$$

$$=\left(B'x_T+Ep\right)\left(\frac{s}{L}\tau-2\right);$$

and we have seen that

$$B'=\frac{A}{r_s},$$

and

$$x_T=\frac{Ep\sigma}{A}$$

$$\therefore B'\left(x_\tau-x_T\right)=\left(1+\frac{\sigma}{r_s}\right)\left(\frac{s}{L}\tau-2\right)$$

Consequently, substituting in equation (18), we have

$$2L\left(1+\frac{\sigma}{r_s}\right)\left(1-\frac{s}{2L}\tau\right)=T(\sigma+l$$

Now $\frac{\sigma}{r_s}$ will probably be negligible and $s\tau=slT$,

therefore we have

$$L=\frac{T}{2}(\sigma+2ls);$$

hence the effect of the short-circuiting is to diminish the value of σ by $2ls$.

Let two observations at speeds of rotation N_1 and N_2 revolutions per minute be made, giving apparent increases of resistance σ_1 and σ_2, then, since

$$T_1=\frac{60}{2N},\quad\text{and}\quad T_2=\frac{60}{2N_2},$$

we have

$$L=15\,\frac{\sigma_2-\sigma_1}{N_2-N_1}.$$

The following is a sample of the results obtained by using this method with the solenoid previously employed, of which the resistance is about 4 ohms, and the coefficient of self-induction 0·0215 secohm.

N	$s+\sigma$
0	4·13
850	5·20
1030	5·50
1230	5·80
1490	6·20
1650	6·40
1610	6·35
1100	5·57
980	5·4
890	5·3
710	5·0

Plotting these results on squared paper, and determining the value of $\frac{\sigma_2-\sigma_1}{N_2-N_1}$ from the mean slope of the line L was found to be about 0·0216, a result very near the truth. Subsequent experiments, however, did not give nearly as accurate results, possibly on account of some unknown resistance in the commutator, and that leads to one reason why the method is much inferior to the use of the secohmmeter, in that the commutator is in one of the arms of the bridge, so that any unknown variation of the resistance of the contacts introduces an error into the test, which, as already explained, cannot happen with the secohmmeter, as neither of the commutators is in any one of the four arms of the bridge. This method, therefore, is distinctly inferior to the use of the secohmmeter.

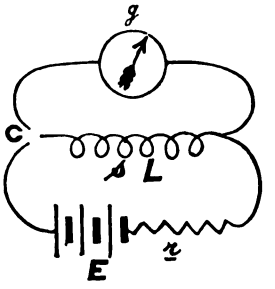

FIG. 10.

Fig. 10 shows another plan tried by Mr. Sumpner, which is cumulative, and although not a zero method, the deflection of the galvanometer from zero is entirely due to the effects of self-induction the coefficient of which is to be measured; the method, therefore, is fairly sensitive, although inferior, of course, to a zero method. By means of the commutator, C, the coil of resistance, s, ohms, and coefficient of self-induction, L, is put first in circuit with a battery of E.M.F. equal to E volts, which may be unknown, and a resistance the value of which together with that of the battery is r ohms, and next with a galvanometer of resistance g ohms; the alternation being produced N times per minute, a speed which must not be too great to prevent the current reaching its steady value each time that the coil is connected with the battery, and to die away in the coil each time that it is connected with the galvanometer. Let D_0 be the galvanometer deflection when the battery and resistance are connected directly in series with the galvanometer, so that

$$D_0=\frac{E}{b+g},$$

and let D_1 be the mean deflection obtained with the commutator working then

$$D_1=\frac{N}{60}\cdot\frac{L}{s+g}\cdot\frac{E}{b+s};$$

$\therefore$ eliminating E, we have

$$L=\frac{60}{N}\cdot\frac{(s+g)(s+b)}{b+g}\cdot\frac{D_1}{D_0}$$

To prevent sparking it would be necessary to connect the coil with the galvanometer for a short time before disconnecting it from the battery, and a small correction would have to be applied, depending on the time that the coil was connected with both galvanometer and the battery. This correction takes the form given by the formula

$$L=\frac{60}{N}\cdot\frac{(s+g)(s+b)}{b+g}\cdot\frac{D_1+l\,m\,D_0}{D_0},$$

where l is the ratio of the time of a short circuit to the time of an alter

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nation, and m is a numerical function of the resistances, such that when b is nought m is equal to $\frac{s}{g}$.

By taking two readings, D_1 and D_2, at speeds N_1 and N_2, we eliminate n and obtain

$$L = \frac{60}{n D_0} \cdot \frac{(s+g)(s+b)}{b+g} \cdot \frac{D_1 - D_2}{N_1 - N_2},$$

where n is the ratio of the E.M.F. used when the commutator is revolving to that used when it is at rest.

This method is suitable for employment in cases where only very small direct currents can be employed, as, for instance, in testing the coefficient of self-induction of a high-resistance Thomson galvanometer without removing the needles. But far greater sensibility is obtained by using the method previously described, in which the coil with self-induction is rapidly reversed, since with that method far stronger currents can be sent through the galvanometer, as the effect of rapidly commutating the terminals of the galvanometer the coefficient of self-induction of which is to be measured is to send alternating currents through it. These alternating currents do produce a deflection, but the deflection is but small, so that the strength of the current that can be employed is only limited by the gauge of the wire wound on the galvanometer that is being tested.

APPENDIX II.

Non-Zero Use of the Secohmmeter.

I. In what has preceded we have supposed that the secohmmeter was turned at such a speed, and the resistance of the arms of the bridge so adjusted that the galvanometer needle was brought to the zero it would stand at if no current whatever were passing through the galvanometer. But that is not necessary, for equation (13) may be written in the form

$$Q_1 = E \frac{(qr - ps)\left(T - \frac{B}{A}\right) - p\left(L + \frac{p+r}{p}M\right)}{A},$$

where p, q, and r are any resistances in the arms of the bridge (Fig. 7, page 59), and s the resistance of the coil under test. Also

$$Q_2 = E \frac{(qr - ps)}{A} \cdot \frac{\lambda}{g},$$

therefore generally the current that will pass through the galvanometer when the secohmmeter is turning at n revolutions per second is

$$n(Q_1 + Q_2) = \frac{nE}{A}\left\{(qr - ps)\left(T + \frac{\lambda}{g} - \frac{B}{A}\right) - p\left(L + \frac{p+r}{p}M\right)\right\} \quad (19)$$

producing a deflection, d, say.

If the secohmmeter be stopped and steady currents employed let balance be obtained by increasing s to $s + \sigma_1$, the values of p, q, and r remaining as before, and let a deflection d' be produced when σ_1 is changed to σ_2, so that d' is the deflection produced by a current

$$\frac{Ep(\sigma_1 - \sigma_2)}{A}.$$

Hence, since $$qr - ps = p\sigma_1,$$

we obtain from (19)

$$\frac{d}{d'} = \frac{n\left\{\sigma_1\left(T + \frac{\lambda}{g} - \frac{B}{A}\right) - \left(L + \frac{p+r}{p}M\right)\right\}}{\sigma_1 - \sigma_2} \quad \ldots (20)$$

Let $$d = l\,d',$$

where l is the lead of the secohmmeter, then we have from (20)

$$L + \frac{p+r}{p}M = \frac{l}{n}\sigma_2 \text{ approximately} \quad \ldots (21)$$

Now σ_2 may be regarded as the apparent increase of resistance of the coil produced by the self-induction on turning the secohmmeter at the rate of n revolutions per second when the zero used in measuring the resistance with steady currents is at a distance d' from the true zero, and the zero used in obtaining balance with the secohmmeter revolving is at a distance $l\,d'$ from the true zero. This leads us to the following *simplified* method of measuring L the coefficient of self-induction, or $L + \frac{p+r}{p}M$ if there be also mutual induction, without its being necessary to *accurately* measure the true resistance of the coil at all.

1. Let a *rough* approximation be made to the resistance of the coil, using steady currents, and let the resistance of the coil appear to be s ohms when the spot of light is somewhere near the zero—say at 130 divisions from the zero.

2. Let the secohmmeter rotate at n revolutions per second, and let the coil now have an apparent resistance of $s + \sigma$ ohms when the spot of light is brought, not to zero, but to $l \times 130$ divisions on the scale; then

$$L = \frac{\sigma}{n}$$

or $$L + \frac{p+r}{r}M = \frac{\sigma}{n}$$ if there be also mutual induction.

II. At the commencement of this paper it was mentioned that we originally measured the coefficient of self-induction, not by altering the resistance in one or more of the arms in order to obtain balance, but by leaving the resistances in the arms unaltered, and observing the galvanometer deflection when the secohmmeter was rotated. Equation (19) at once gives the formula that we employed with that method of using the secohmmeter, for if p, q, and r be the resistances of the arms that will produce balance with s for steady currrents, equation (19) becomes

$$n(Q_1 + Q_2) = -\frac{nEp}{A}\left(L + \frac{p+r}{p}M\right);$$

let this current $n(Q_1 + Q_2)$ produce a deflection d_1. Next let s be increased by a known resistance s', and let the galvanometer deflection for steady currents in the arms be d_2, then this deflection is produced by a current

$$-\frac{Eps'}{A}$$

$$\therefore \frac{d_1}{d_2} = \frac{n}{s'}\left(L + \frac{p+r}{p}M\right)$$

or $$L + \frac{p+r}{p}M = \frac{d_1}{d_2} \cdot \frac{s'}{n}$$

or $$L = \frac{d_1}{d_2} \cdot \frac{s'}{n}$$ if there be no mutual induction,

the formula originally employed for measuring L.

This comparative deflection method of using the secohmmeter has received a high testimonial for great sensibility from MM. P. Ledeboer and G. Maneuvrier, who, unaware of the fact that it was devised and used by us rather more than a year ago, have recently brought it to notice in France. The large amount of excellent work that M. Ledeboer has done on self and mutual induction makes him well competent to judge of the relative sensibility of methods of measuring the coefficients; therefore we feel sure that he and his colleague will be the first to recognise the great increase of sensibility of our *zero cumulative* method beyond even the sensibility possessed by our *amperative deflection cumulative* method for measuring the coefficients of self and mutual induction.

Use of Secohmmeter without Speed Indicator.

III. It is important to notice that *all* known zero galvanometric methods of comparing the coefficients of self or mutual reduction with one another, or with the capacity of a condenser, can be increased *enormously* in sensibility by the use of the secohmmeter, and since in such cases the speed of rotation need not be known, a very simple form of secohmmeter without speed indicator can be employed. The comparison of the coefficients of self or mutual induction with one another, or with the capacity of a condenser, is usually effected by tests that are completed during the growth or the dying away of a current, since it is during the variation of a current that self or mutual induction, or the electrostatic capacity of a condenser evidence themselves. The effect of an error in the balance only lasts for a very short time, and therefore is very small if the error be small—that is, the tests are not sensitive. Resistances are compared with steady currents lasting for a considerable time, but before attempting to accurately measure an unknown resistance it is a common practice to give the bridge key a tap to see whether the balance is so far out that a deflection of the galvanometer is produced for a current lasting for a very short time. Such a preliminary test is intentionally very unsensitive, but its sensibility is equal to that of the ordinary tests made for comparing the coefficients of self and mutual induction. But by the use of the secohmmeter it is now possible, not merely to measure the coefficient of self and mutual induction and the capacities of condensers *absolutely*, but, in addition, *to secure the same high degree of sensibility with tests that have hitherto had to be completed during the growth and dying away of a current that it is customary to obtain in the use of the Wheatstone bridge for measuring resistances with steady currents.*

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of this Society at the Institution of Civil Engineers on Thursday, 26th May, Dr. Hopkinson in the chair, the Secretary read a paper by Mr. C. T. Fleetwood on "Underground Telegraphs."

After referring to his previous paper on this subject in 1875, Mr. Fleetwood thought that some account of the results of the work then carried out would now be acceptable to the Society First, however, he would remark that although we take a great deal of credit for our system of insulated underground telegraph system, the real originator was Mr., afterwards Sir, Francis Rolands, who, in his garden at Hammersmith, as long ago as 1816, demonstrated the practicability of the idea; and who, in his book dated 1823, described by anticipation the methods that would probably be employed in future work of that kind. His trough of wood, 525ft. long and 4ft. deep, with buried glass tubes, into which copper wires were drawn, may be regarded as the germ of the present underground telegraphs. Moreover, he suggested the laying of wires along the high road, with testing points at convenient intervals, and men stationed there to look after faults. He clearly saw the commercial value of the telegraph long before it became a practical reality; and some portion of his cable, now the property of Mr. Latimer Clark, and which was there for inspection, would be found to be in as good condition as any we could produce nowadays. Coming to the period of 1837, when Cook and Wheatstone took out their first patents, the year from which we date the Jubilee of the Telegraph, their scheme included an underground telegraph; and five wires were thus carried in grooved wooden troughs, and covered with pitch, from Euston-square to Camden-road, a specimen of which was now on view. In the following year an iron tube was employed for enclosing the wires on the Great Western Railway between Paddington and West Drayton. India rubber and tape were also used on this occasion. For overhead wires the first poles were erected from Nine Elms to Gosport, part of the way through London in lead tubes of 50 yards sections, and

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the wires served with tar and grease. Portions of this were recently recovered, and were found after an interval of 40 years to be well insulated and the tar perfectly fresh. Nevertheless, the wires on the whole were frequently faulty, and the wonder was that communication over any long distances could be maintained at all. The remedy came in the discovery of gutta percha, an effectual insulator; and between 1842-5 some of this material was employed for that purpose. Not however, till 1847 was any patent taken out for its use specifically as a dielectric, and for a considerable time, although the material was purer and far better than we can get it now, the manufacture and manner of covering the wires were very imperfect. The Electric Telegraph Company, on the occasion of their transferring their headquarters from the Strand office to the new office in Lothbury, served their wires with cotton covering, and drew them into iron tubes; and soon after connected them with several of the principal railway stations in the same way. It was in 1849 that the first gutta percha covered wire was introduced between the city and Shoreditch station. From that time the employment of gutta percha covered wires rapidly increased, and by the year 1854 the company just mentioned owned 350 miles of such wires. In 1850 the Submarine Telegraph Company had laid down similar wires to Dover in connection with their cable to France, and in 1853 which was a very busy year for the telegraph of this country, underground wires were carried along the London and North-Western Railroad from London to Manchester by the Electric (now the Electric and International) Telegraph Company, and a number of lines were also established by the British Company, which had started in competition with the Electric, chiefly along the main roads, whilst the Magnetic, another competing company, started wires to Liverpool, as well as in Cork and Queenstown. These two companies soon combined and worked in opposition to the old company. Mr. FLEETWOOD here described the general methods of laying down these wires. In some instances the gutta percha was their only covering; in others they were served also with tarred tape. The outer tubing for some portion of these lines was of earthenware instead of iron. These were completed in 1855, but a few years after were condemned and put up on poles. Their failure was attributed to the gutta percha covering, and the material was sold for less than a third of what it had cost. Portions of it, however, were left; and on its recovery recently such of it as had been served with tarred taping is found to be in splendid condition, though not when enclosed in wooden troughs, except where the position was particularly favourable. Nor was the split iron pipe of that period much better than wood. Solid iron pipes are now invariably used and the wires drawn in. The danger from inroads of gas to split pipes is very great; and as regards earthenware, being jointed with clay, tree roots often found their way into such tubes, and completely destroyed the work. It may be said of the work of that period generally that it was too hurriedly done, the men were ignorant and inexperienced, and the supervision was not as well informed or as careful as now. The United Kingdom Company—a later enterprise—for example, made the mistake of using split pipes under the footway, and were soon broken down in consequence. Coming to the year of the transfer of the telegraphs to the Post Office in 1870, the necessity for recovering and increasing the number of underground wires enabled us to discover many faults and the causes of them; and in 1874, on the removal from Telegraph-street to the new Post Office premises in St. Martin's-le-Grand, advantage was taken of the lessons thus learned. There was at that time an outcry against overhouse wires, though the telephone had not yet been invented, and the occasion was seized to lay all the Post Office wires underground by the most approved methods. Then came the telephone and with it the necessity for cabling large numbers of fine twisted wires in comparatively small pipes The plan of Mr. David Brooks for insulating wires by means of liquid oil was here described, thirty or forty of them being insulated in that way in pipes between Waterloo and Clapham Junction Stations. The experiment has answered well and deserved to be tried on a larger scale, provided the leakage of oil, which has been considerable, can be obviated. At present the Post Office possesses in the metropolis about 240 miles of tubes containing 12,000 miles of wire, or an average of 50 wires for each tube, and these are continually being taken out and increased, the flush boxes which occur at every 50 yards or thereabouts serving admirably for this purpose, without the necessity for ever breaking down the circuits. For simplicity, efficiency and durability, Mr. FLEETWOOD, after many years' experience, considered that the system of gutta percha covered wires in iron tubes, such as he had described, could not be surpassed.

A number of specimens of cables of various ages, some of them of great historical interest, were exhibited in illustration of Mr. Fleetwood's paper.

Colonel WEBBER suggested that the cause of deterioration of modern gutta percha wire was due to adulteration. Some he had inspected which was laid down at Lowestoft twenty years ago was still as good as new. None such is obtainable now; and this fact accounts for the discreditable character of much of our modern work. He laid stress on the importance of completing that system which, in his recollection, was inaugurated by Mr. Culley, and carried out by Mr. Shipp—a system which enables us to renew, repair, or enlarge at pleasure without interrupting the electrical continuity. Colonel Webber then made an earnest appeal to capitalists who are interested in telephonic extension, that they will exercise some ordinary foresight in respect to their present overhouse telephone wires. It is obvious that these wires cannot be allowed to go on indefinitely increasing; and it is high time that some plan be started to meet the requirements of, say, ten years hence. The interval between now and the expiry of their patents, and the period when the public will endure the net work of overhead wires no longer, should be utilised by laying aside capital, and by carefully and cautiously establishing conduits wherein these wires may some day all be securely buried out of sight.

Mr. A. J. S. ADAMS questioned Mr. Fleetwood as to the durability of the underground work completed in 1875, and generally defended overhead wires.

Mr. W. H. PREECE stated with reference to the wires in earthenware tubes between Liverpool and Manchester, that the wires would apparently last for ever, but that the tubes had had to be replaced by iron ones, for reasons mentioned by Mr. Fleetwood. Referring to the historical portion of Mr. Fleetwood's paper, Mr. Preece expressed the opinion that Roland's paper in 1823 would do credit to any electrical engineer to-day, such was his insight and almost prophetic instinct with regard to the then remote future of the electric telegraph. Hardly less to be complimented in the practical branch of the subject was Mr. C. F. Varley, whose wonderful method of testing with his differential galvanometer rendered the employment of underground wires permanently available by discovering their faults without digging up the wires. He concurred in the view that gutta percha had greatly deteriorated; but, in spite of that fact, nothing better had been used as yet for outdoor work. But while the dielectric had gone down in quality the wire had decidedly gone up, the copper now being introduced giving immensely better results in telegraphy and telephony than any formerly obtained on either copper or iron. Brooks' system of insulation had not failed, but it could not be described as very successful. On the other hand, some results of bituminous covering were very remarkable, as shown that night; and an invention lately brought over to this country from America by Mr. Eddison was highly promising. It consisted of a dielectric of resin oil and resin, a dry compound, covered with lead. The tests gave 19,000 megs. per mile when the specimens were first brought over, and on re-testing lately their condition remained unchanged. On the question of underground wires for the trunk lines, although there were electrical as well as financial objections to their adoption, some good grounds existed for the establishment of a certain number of such lines to important centres throughout the country; and if Parliament would only sanction the expenditure of the two-and-half millions necessary for the operation, the present Postmaster-General was anxious to have it done; and possibly such an invention as that introduced by Mr. Eddison might greatly reduce the commercial as well as electrical drawbacks to the scheme. Even now we have more underground wires—25,000 miles—than any other European country.

Mr. ALEXANDER SIEMENS made mention of the early attention given to gutta percha by Dr. Werner Siemens, and of the fact that the compound with which the submarine cables recently laid by Siemens Brothers had enabled those cables to be duplexed, which could not be done with other cables.

After a few observations from Mr. EDDISON and Mr. BELL, Mr. FLEETWOOD briefly replied, chiefly in regard to wires laid down since 1870, which he said showed no signs of decay, except where they had been chafed by careless drawing through the iron tubes without a serving of tape.

A short paper on "Driving a Dynamo with a Very Short Belt," by Profs. AYRTON and PERRY, was then read by the first-named gentleman.

PHYSICAL SOCIETY.—May 28.

Prof. W. E. AYRTON, Vice-President, in the chair.

Dr. S. P. THOMPSON read a note on *Transformers for Electric Distribution.*

In the simple algebraic treatment of the dynamo several assumptions approximately true for well-made machines are made use of. The author finds that a similar set of assumptions for transformers greatly simplifies the algebraic theory.

1st. The iron, copper, and insulation are assumed good. 2nd. The reaction of the secondary on the primary (other than that desired) is small. Thus, if the primary be supposed to be supplied with constant mean current or constant mean potential difference, this is not to be altered by the current in the secondary. 3rd. No magnetic leakage; so that the coefficient of mutual induction is the geometric mean between their coefficients of self-induction. 4th. The quantity of copper in the primary and secondary are to be equal. These assumptions are shown to be legitimate, and the ratios of resistances, E.M.F.'s, currents, and coefficients of self-inductions are expressed in terms of the ratio of the numbers of convolution, which ratio is represented by $p = \frac{S_1}{S_2}$. From analogy with the dynamo it is shown that $E_2 = \frac{\omega M E_1}{\sqrt{R_1^2 + \omega^2 L_1^2}}$, where $\omega = 2\pi n$, E_1 and E_2 the E.M.F.'s of the primary and secondary respectively, and R_1 and L_1 the resistance and self-induction of the primary coil. If R_1 be neglible, the above reduces to $E_2 = \frac{\omega M}{\sqrt{\omega^2 L_1^2}} E^1 = \frac{E_1}{p}$ since $\frac{L_1}{L^2} = p^2$, and $M = \sqrt{L_1 L_2}$.

The latter part of the paper contains a general investigation of two neighbouring circuits, both having self-induction, and it is shown that the effective resistance of the primary is increased and the self-induction decreased by closing the secondary circuit.

Mr. KAPP said the investigations assumed the coefficient of induction to be constants, and that the phases of current in primary and secondary were opposite. The former being by no means true, he asked what values were to be taken; and he believed the phases of current are not opposite in ordinary transformers.

Mr. SWINBURNE protested against the use of formula to calculate the inductions when the required data could be obtained much more accurately from Dr. Hopkinson's curves on magnetisation of iron. He also thought the curve of sines did not nearly represent the current curve for ordinary machines.

Mr. BOSANQUET thought the effective magnetisation of a transformer

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would be different to that of a dynamo, for in the former permanent magnetism was not utilised.

In reply to Mr. Kapp and Mr. Swinburne, the AUTHOR pointed out that as the coefficients of induction enter in both numerator and denominator, it would not matter which set of values were taken if the resistance was small compared with ω L; and that self-induction tends to smooth out irregularities in the current curve. Prof. AYRTON described a method of regulating a series transformer devised by himself and colleague some two years ago, based on analogy with a compound dynamo. Referring to the variation of L with current, he sketched a curve connecting them, obtained by Mr. Sumpner at the Central Institution, and mentioned that the E.M.F. curve of a Ferranti dynamo is an exact sine curve. He believed problems involving alternating currents would be greatly simplified by using a new set of measurable quantities, such as would render the equations as simple as possible. At Prof. Thompson's request Prof. Ayrton exhibited a lecture experiment illustrating the action of transformers. The secondarys of two ordinary induction coils were joined in series through long fine wires, and an incandescent lamp placed in the primary circuit of one lighted up on completing the primary of the other coil, in which a battery was placed.

On Magnetic Torsion of Iron Wires, by SHELFORD BIDWELL. This is an account of experiments made on the twisting produced by sending a current along magnetised iron wires, and the author shows that Wiedemann's explanation of these phenomena (by assuming a difference in molecular friction at the polar and lateral surfaces of magnetised molecules) is unsatisfactory. The wires were magnetised longitudinally by means of a solenoid, in the axis of which the wires were suspended. To obtain consistent results it was found necessary to demagnetise the wire between the observations. This is done by several currents of gradually decreasing strength, and a simple arrangement of rheostat and commutator devised for this purpose was exhibited.

Two sets of experiments were made, in which the current in wire or solenoid was kept constant, whilst that in the other was varied. The amount of twisting does not increase continuously when the currents are increased, but attains a maximum when the inclination of the helix, representing the director of magnetisation, is inclined at about 33deg. to the axis of the wire. When the current in the solenoid was kept constant, and that in the wire increased, a permanent deflection remained on stopping the current. For small currents in the wire this deflection was diminished on starting the current, whilst stronger currents increased the deflection. For some intermediate value of the currents no change took place, and this value was dependent on the current in the solenoid. Experiments were shown illustrating these phenomena.

COMPANIES' MEETINGS.

The Consolidated Telephone Construction and Maintenance Company (Limited).

The sixth annual general meeting of the shareholders in this Company was held at the City Terminus Hotel, Cannon-street, yesterday, under the presidency of Mr. C. L. W. FitzGerald.

The SECRETARY (Mr. Chas. Curtoys) read the notice convening the meeting, and the minutes of the last meeting were taken as read and confirmed by the present meeting and signed by the Chairman. The report of the Directors and statement of accounts were also taken as read.

The CHAIRMAN: Gentlemen, on this occasion of my rising to address you I do so with considerable satisfaction, for an event has taken place which has placed us in a position to do something a little out of the common, and that is the amalgamation of the River Plate Telephone and Electric Light Company with the United Telephone Company of the River Plate. You will see that, as a consequence of this amalgamation, the shares held by this Company in the late River Plate Telephone Company have ceased to exist. We have received a large sum owing to us—no less than £10,277—from the River Plate Company, also £1,250 as a compromise of the contract which that Company failed to fulfil for the supply of telephones. Further, the cumulative 9 per cent. dividend, amounting to £1,838, has been paid to us, and an amount standing in our books at the sum of £9,256 has now been converted into £8,985 in shares of the United River Plate Telephone Company (Limited) at par, and £11,554 in cash has also been received. There is also a very considerable sum of money to be received from this amalgamation. Of course it is very difficult to know how much that will amount to; but I think, roughly speaking, I might put it down at somewhere about £8,000, perhaps more. But that depends very much upon how the business in the River Plate is regulated—in other words, upon whether we get a good price or not for the assets that we have over there. Now, gentlemen, this £11,564, having come to us, so to speak, from the sale of the shares which we held in that company we, the Directors, are in this position, that we have got a sum of money which we did not know very well what to do with, and, with the consent of our auditors, we came to the conclusion that it would be much better to hand that money back to the shareholders in the form of 1s. per share, reducing the capital by the like amount, than anything else. I will explain that to you by this. You see we have got against the capital, expenditure, goodwill, patent rights, &c., £87,000. Now, we are going to reduce that at once by £11,564, which of course, to a certain extent, places our business in a better position really, in so far as we shall be able to pay bigger dividends on the smaller amount of capital which we shall have to deal with in the future, the shareholders meanwhile getting the 1s. back into their own pockets. I think, gentleman, that should be very satisfactory to you. I wish just to make one other remark in this connection. There seems to exist in certain shareholders' minds some confusion as to this reduction of capital. They appear to confuse it with the 5s. reduction of capital which was lost during the late management. Now this is, so to speak, a sum of money which we are going to pay absolutely to the shareholders and not to take away from them, and you will at once see that there is a very great difference between the two cases. We propose doing that, and to do it we shall have to call an extraordinary general meeting after this one that we are now holding, and then we shall have to go to the Court to obtain the necessary powers to pay you back that 1s. I am very happy to state that the Board decided that we should exhibit our telephones at the Exhibition at Brussels, and that on all hands, in the Belgian press and elsewhere, it was admitted that our instruments were really first class. The only thing I have got to say about the subject is this, that unfortunately people abroad want things cheap. They do not care for a high-class instrument, and it is a very difficult thing to do to make a cheap instrument which you can really call high class. This fact, however, has led to a considerable number of inquiries from various places, and we hope that some good may arise in the shape of an increased sale of our telephones by having exhibited them at Brussels. You heard at the last meeting that we desired, and we asked your permission, to join the Edison-Gower-Bell Telephone Company in a law suit to prosecute infringers in Belgium. So far we have obtained permission of the Courts to bring our action, which, of course is a great step. We have now got to prove that our patent is the master patent of the telephones which are used in that country. I have no doubt that the trial will take place shortly, but I need not remark to you that everything has been done to try and put obstacles in our way. They have stopped us as much as they possibly could by laying before us the enormous amount of damages which the infringers will sustain for their not being able to use the telephones, and one thing or another; but up to the present time everything has gone satisfactorily for us. That is a source of profit that may possibly some day astonish us. I cannot say it will, but it may. The next point that I have to allude to is that we had certain machinery in the factory which did not belong to us. Now, that was a very unsatisfactory position to be in, because at a moment's notice possibly something might have happened that would have caused the machinery to be taken away, and the opportunity having occurred, we thought that it would be best to buy that machinery at once, which we did, so that it all belongs to the Company now, and we are in as perfect a position for manufacturing purposes as we possibly could be. I think you will approve of that step. I think myself that it was a very wise one indeed to take. The next point I have to draw attention to is that you will see that our subsidiary companies are steadily improving, which I regard as very encouraging, because it leads one to believe that sooner or later those companies will be a great support to us. You will also see that the two remaining companies—the Telephone Company of Austria and the Edison-Gower-Bell Company—have increased by no less than 683 subscribers with an annual rental of £4,402. Gentlemen, it is with very sincere regret that the Board have to announce the death of one of their colleagues. Mr. John Taylor was a man of exceptional ability and of great business capacity, and I am sure he rendered the Company great service. I may tell you that he died absolutely in harness. Major FitzGerald and Mr. Bateman have also retired from the Board to take their seats on the Board of the United River Plate Telephone Company. I think the thanks of the shareholders are due to these gentlemen for their past services. I very much regret that they have to leave us, but they have gone on to the Board of that company to look after our interests. Therefore, I think we ought to be very much obliged to them for resigning their seats. The figures for the year I will now read to you. They show a net profit of £8,957, which with the amount carried forward leaves a balance of £10,127. We are about to propose to you that this shall be dealt with by paying you a further dividend of £2. 10s. per cent., which will make, with the interim dividend in November last, 5 per cent. for the year. We have further written off £558 for depreciation of plant, machinery, and furniture, leaving £1,695 to carry forward. We have kept our stock down. It now stands at the amount of £3,658, and I am also happy to state that though that is principally due to the River Plate Company having paid us the £10,000 odd which they did, the money owed to us is not quite so gigantic as usual, the total amount being £8,144, of which we have reserved £1,487 against any possible non-receipt of moneys. There is one other matter that I should like to allude to. You will see that the Edison-Gower-Bell Telephone Company's 20,000 preference shares of £1 each and the 15,000 ordinary shares of £1 each have been reduced in value—in other words, we have written down that value, roughly speaking, by £4,000, thereby really placing that security on a more satisfactory footing, to be dealt with at some future date. I am happy to say that our United River Plate Company's shares, of which we hold 1,797, are now quoted on the Stock Exchange, and are a marketable security standing at a premium. I think that is cause for congratulation among the shareholders. The Telephone Company of Austria, in which we have £34,000 debentures at par, has paid its interest regularly, and is now in a position to state that it is really earning a dividend of which we shall now reap the benefit. He concluded by inviting the shareholders to ask any questions they might desire.

A SHAREHOLDER asked whether the River Plate Company was going to be a customer of the Consolidated Company.

The CHAIRMAN expressed a hope that that would be so.

Another SHAREHOLDER asked whether the United Telephone Company took all its instruments from this Company, or were the Directors aware of orders having been placed elsewhere.

The CHAIRMAN: I can only say that we think they take all their instruments from us—we have no reason to suppose otherwise.

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A SHAREHOLDER wished to know whether they had £120,000 invested in Austria.

The CHAIRMAN: No, sir; that you will see is simply a *per contra* item on one side of the account. It is the Austrian capital; but I should explain to you that by the Austrian law that company is not allowed to work; that we, the Consolidated Company, are the Company that are working Austria for another company. We are in this position there, that we are now applying to the Courts to enable the Telephone Company of Austria to work the business in place of the Consolidated. It is perfectly independent; but by Austrian law we are obliged to put the item in our balance-sheet. I should tell you that the Edison-Gower-Bell shares are a growing asset, the same as that £28,000 in the Telephone Company of Austria is a growing asset. They are improving in value every day, I consider. What the value of them is I cannot fix. If you like to make a bid for the shares you may, of course, find it out in that way.

A SHAREHOLDER: Why are they not included in the assets?

The CHAIRMAN: Because they are against the £87,000 capital expenditure. They will become an asset I hope some day, and pay us a dividend. I shall be very much mistaken if they do not; I never lose sight of those shares, for they are a growing asset.

The AUDITOR (Mr. Griffiths), in reply to another shareholder, said that the reason why those shares which were referred to in the accounts in a note were not valued was that they were practically of an unassessable value at the present moment. It would be impossible for the Directors to say what the shares were worth. There was no market for them whatever, and if they put any valuation on the shares now it would be a mere guess, which would have to be varied from time to time, and thus affect the appearance of the balance-sheet without really affecting their position in any respect whatever.

The CHAIRMAN: I will now propose that the statement of accounts, the balance-sheet, and the report of the Directors, as now submitted to the meeting, be received and adopted, and that a final dividend of 2½ per cent. be paid, making, with the interim dividend previously paid, 5 per cent. for the year ended 31st March, 1887.

Sir ALEXANDER ARMSTRONG, K.C.B., seconded the resolution, which was carried unanimously.

On the motion of Mr. A. H. Baker, seconded by Mr. H. Grewing, the retiring Directors, Mr. C. L. W. FitzGerald and Mr. Richard Van-Zeller, were unanimously re-elected to their seats at the Board.

The auditors, Messrs. John G. Griffiths and Arthur E. Green, were subsequently reappointed.

The meeting was then made extraordinary.

The SECRETARY having read the advertisement calling the meeting,

The CHAIRMAN said: Gentlemen, I have already explained to you what the reduction of our capital means, and therefore I will not detain you longer than just to move this resolution:—"That the capital of the Company be reduced from £243,787. 10s., divided into 224,850 shares of 15s. each, and 75,150 shares of £1 each, to £232,545, divided into 224,850 shares of 14s. each and 75,150 shares of £1 each, and that such reduction be effected by returning to the holders of the 224,850 shares that have been issued, paid-up capital to the extent of 1s. per share, and by reducing the nominal amount of such 224,850 shares to 14s. each."

Sir ALEXANDER ARMSTRONG seconded the motion.

The CHAIRMAN, in reply to a question, said that the reason why the money was being paid back was because the Directors found they could not use it.

A SHAREHOLDER asked whether the Company had some claim against Sir Julius Vogel?

The CHAIRMAN replied in the affirmative, but pointed out that it was an exceedingly difficult thing to sue a man in Australia.

The motion was carried unanimously.

The CHAIRMAN: We shall have to hold a confirmatory meeting within a month. We shall send you out the dividend warrants early next week. How long it will take to get the permission of the Court to return you the 1s. per share I cannot tell you, but it will be done as quickly as possible.

A vote of thanks having been passed to the Chairman and Directors the proceedings terminated.

CRICKET.

EASTERN TELEGRAPH COMPANY v. ST. MILDRED'S C.C.

This match was played on the West London Cricket Grounds, Wormwood Scrubbs, on Saturday, the 28th ult., and resulted in a decisive victory for the Eastern Company. Their opponents (mainly composed of *employés* in the Anglo-American Telegraph Company) made no stand against the destructive bowling of Messrs. McMillan and McDonald, their total being 36 runs. The Eastern Company, on the other hand, through the excellent play of Messrs. Hensman and Couper, secured 83 runs, thus leaving them victors by 47 runs. We annex the scores:—

ST. MILDRED'S.—Knowler, b. McMillan, 0; Clarke, c. Launders, b. McDonald, 9; Wran, b. McDonald, 3; Denton, c. Donaldson, b. McDonald, 1; Lester, c. Prosser, b. McMillan, 0; Constant, not out, 6; Alexander, b. McDonald, 0; Griffen, c. McDonald, b. McMillan, 1; Smith, run out, 0; Willis, b. McMillan, 12; Poulton, b. McMillan, 0; extras 4—total 36.

EASTERN TELEGRAPH COMPANY.—McMillan, c. Wran, b. Constant, 6; Prosser, run out, 5; McDonald, b. Constant, 0; Couper, b. Clark, 11; Finlayson, run out, 1; Hensman, b. Constant, 37; Donaldson, b. Clark, 2; Payne, b. Constant, 1; Grigor, b. Clark, 3; Sherlock, not out, 0; Launders, b. Clark, 9; extras 8—total, 83.

EASTERN TELEGRAPH COMPANY v. WALHAM GREEN C.C.

This match was played on the ground of the Walham Green C.C., Beaufort House, on Whit Monday last, and after a most pleasant game the Telegraph Company were declared the victors by an innings and 7 runs. Comment is hardly necessary, the annexed details of the scoring showing the state of game:—

WALHAM GREEN.—First innings—Alsop, b. McMillan, 14; Milner, b. McMillan, 3; Davies, b. McMillan, 5; Redsall, b. McMillan, 7; Wright, c. Lindsay, b. McMillan, 5; Salisbury, b. McMillan, 0; Hawkes, c. Finlayson, b. McMillan, 0; H. W. Smith, c. McMillan, b. Lindsay, 0; Brown, c. Morrison, b. Lindsay, 6; G. Smith, b. McMillan, 0; Pender, not out, 0; extras 1—total 41. Second innings—Alsop, b. G. C. Jack, 1; Milner, c. Finlayson, b. G. C. Jack, 12; Davies, b. G. C. Jack, 4; Redsall, b. Lindsay, 1; Wright, lbw., b. Lindsay, 3; Salisbury, b. Lindsay, 1; Hawkes, b. G. C. Jack, 27; H. W. Smith, not out, 2; Brown, b. Lindsay, 0; G. Smith, b. G. C. Jack, 4; Pender, lbw., b. Lindsay, 0; extras 5—total 60.

EASTERN TELEGRAPH COMPANY.—Prosser, b. Redsall, 28; A. Jack, b Redsall, 15; Finlayson, lbw., b. Redsall, 0; McMillan, c. Milner, b. Wright, 9; G. C. Jack, b. Brown, 39; Launders, hw., 0; Lindsay, b. Wright, 8; J. Morrison, b. Wright, 0; O'Shaughnessy, c. Alsop, b. Milner, 0; J. H. Jack, b. Wright, 0; Grigor, not out, 5; extras 4—total, 108.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 27th May amounted to £4,004.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for May, 1887, amounted to £48,057, and to £50,741 in the corresponding period of 1886.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for May, 1887, amounted to £36,495, and to £41,037 for May, 1886.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 27th May were £3,248, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

NOTICE OF REMOVAL.—Messrs. Norman and Son, electrical engineers, of Glasgow, have changed their business address to 77, Waterloo-street, Glasgow, where they have taken commodious premises.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 1.		BUSINESS DONE WEEK ENDING JUNE 1. Highest.		Lowest.	
Anglo-American	35½,	36½	.....	—	.....	—
Do. Preferred	58½,	59½	.....	59	.....	58½
Do. Deferred	14,	15	.....	14½	.....	14½
Brazilian Submarine	11,	11½	.....	11 5-16	.....	11½
Cuba	12,	12½	.....	12½	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅞,	3	.....	2⅞	.....	—
Do. Preference	7,	8	.....	—	.....	—
Direct United States Cable	9,	9½	.....	9	.....	—
Eastern Telegraph	10⅝,	10¾	.....	10¾	.....	10 11-16
Do. 6 per Cent. Preference	13⅞,	14½	.....	—	.....	—
Do. 5 per Cent. Debentures, 1899	107,	110	.....	—	.....	—
Eastern Extension	11⅛,	11⅜	.....	11 11-16	.....	11 9-16
German Union	10½,	11	.....	—	.....	—
Globe Telegraph and Trust	5½,	5⅝	.....	5⅝	.....	5⅝
Do. Preference	12⅜,	13	.....	13	.....	12 13-16
Great Northern	13¾,	14	.....	14	.....	13¾
Indo-European	34,	35	.....	35	.....	—
Reuter's	7⅞,	8½	.....	—	.....	—
Submarine	180,	190	.....	—	.....	—
West India and Panama	⅝,	¾	.....	—	.....	—
* Do. 1st Preference	8½,	9	.....	8¾	.....	8½
Western Brazilian	8,	8½	.....	8½	.....	8
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	102,	105	.....	—	.....	—

* x.d. 6s. on account of arrears.

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	¾	.....	¾	.....	13-16
Oriental	½,	⅝	.....	—	.....	—
United Telephone	13,	13½	.....	13 7-16	.....	13⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅞,	3⅛	.....	2 15-16	.....	—
Do. (fully paid)	4,	4½	.....	—	.....	—
Swan	1⅜,	1⅝	.....	—	.....	—
Maxim Weston	3-16,	5-16	.....	¼	.....	—

MISCELLANEOUS.

Telegraph Construction	36,	37	.....	36¾	.....	36¾
India Rubber, Gutta Percha, and Telegraph Works	23,	24	.....	23¾	.....	23⅝

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NOTES.

CABLES REPAIRED.—The cable of the Paris and New York Telegraph Company has been successfully repaired.

GLOUCESTER.—A telephone exchange has been opened in this town by the Western Counties and South Wales Telephone Company.

BENACRE HALL, LOWESTOFT.—Benacre Hall, near Lowestoft, which has been leased by Sir Arthur Guinness, is being fitted with electric light.

THE ELIESON ELECTRIC LOCOMOTIVE.—The Elieson locomotives commenced running upon the North London tram lines at Stratford on Monday last.

"WINDING MAGNETS FOR DYNAMOS.—Messrs. E. and F. N. Spon send us a copy of "Practical Directions for Winding Magnets for Dynamos," by Mr. C. Hering, of New York.

THE WEST COAST OF AFRICA CABLES.—Telegraphic communication has now been established with the following places on the West Coast of Africa, viz. :—Winnebah, Salt Pond, and Cape Coast Castle.

MEXICO.—Advices from the City of Mexico state that permission has been granted to an electric light company now putting in a plant at Puebla to utilise the water-power furnished by the River Atoyac.

FREEMASONRY.—Bro. James Hookey was installed W.M. of the Electric Lodge (No. 2,087) at the Mitre Hotel, Hampton Court, on the 28th ult., and Bro. W. H. Preece was presented with a handsome Past-Master's jewel on his retiring from the chair.

FATALITY BY LIGHTNING IN FRANCE.—On Sunday last at Figeac, in the department of Lot, during a heavy storm the church was struck by lightning. About thirty people were praying in the church at the time, and of these two women were killed and one man was severely burned.

THE RETIREMENT OF PROF. TYNDALL.—On his retirement from the chair of Natural Philosophy in the Royal Institution, Prof. Tyndall has been invited to a complimentary dinner at Willis's Rooms to be held on the 29th inst. The President of the Royal Society will take the chair.

TENDERS WANTED FOR PUBLIC LIGHTING.—Tenders are being invited for lighting the town of Alford "with gas or other light" up to May, 1888. Further information may be obtained from Mr. E. W. Rushton, town clerk, Alford, Lincolnshire, and tenders will be received up to the 25th inst.

BRIGHTLINGSEA, ESSEX.—The streets of this little town are at present lit by oil lamps. A motion to invite tenders for gas lighting has just been rejected by the local authorities by a small majority. It is questionable whether an electric lighting scheme would meet with any better fate, but it might be worth a trial.

ELECTRIC LIGHTING OF THEATRES MADE OBLIGATORY.—At Lyons the Mayor has issued a decree to the effect that in view of the recent deplorable catastrophe at the Opera Comique, all theatres, café concerts, and other public buildings in Lyons are, within five months from the present time, to be lit throughout by electricity.

THE POSTAL TELEGRAPH SERVICE.—In another column will be found an abstract of the recent debate in the House of Commons on the present position of the Postal Telegraph Service. The Postmaster-General has replied to the recent memorial, signed by the telegraphists at the Central Telegraph Station, on behalf of some amelioration of their position. Mr. Raikes expresses regret at his inability to accede to their wishes.

"FIVE FIGURE LOGARITHMS."—We have received a copy of "A B C Five Figure Logarithms, or logarithms with differences on a new and simpler plan, together with analytical factors, gas reduction tables, and other tables useful in physical and chemical laboratories, by Mr. C. J. Woodward, B.Sc., Principal of the Chemistry and Physics Department of the Birmingham and Midland Institute," published by Simpkin, Marshall and Co.

ROYAL METEOROLOGICAL SOCIETY.—At an ordinary meeting of this society, to be held at the Institution of Civil Engineers, at 25, Great George-street, Westminster, on Wednesday, the 15th inst., at 7 p.m., the following amongst other papers will be read :—"Note on a Display of Globular Lightning at Ringstead Bay, Dorset, on 17th August, 1876," by H. S. Eaton, M.A., F.R.Met.Soc.; "Ball Lightning seen during a Thunderstorm on 11th July, 1874," by John W. Tripe, M.D., F.R.Met.Soc.

THE ITALIAN GOVERNMENT AND THE TELEPHONE SERVICE.—The Commission appointed some time since by the Italian Government to consider the relation of the telephone service to the State telegraphs has presented its report. The principle that the monopoly of electric communication rests with the Government is laid down, but it is recommended that concessions for 20 years be accorded to established exchanges. Long-distance lines will also be permitted on the basis of a percentage of profits being paid to the Government.

A LONG RUN AT MONTREAL.—The Edison dynamo and Armington and Sims engine supplied to the St. Lawrence Sugar Refining Company, of Montreal, four years ago, are reported by Mr. A. J. Lawson as still in perfect condition. The commutator of the dynamo has only worn $\frac{1}{8}$in. in diameter in that time, although run day and night from Monday morning till midnight Saturday the year round without cessation. One set of brushes only have been used in a year, and both engine and dynamo have made the long run of forty-two days and nights, or 1,008 hours, without stop. Several of the lamps have given a life of 7,000 hours, and are not yet burned out.

THE RATING OF TELEPHONE WIRES.—At a meeting of the Glasgow Town Council it was reported that the attention of the assessor had been called to the telephone wires or apparatus in the city parish, and to request him to have them inserted in the valuation roll. Mr. Brechin said it had appeared to the committee that telephone wires should be assessed in common with telegraph wires, water and gas pipes, and many other things. The wires were erected by a company trading for profit, and it was only right that they should contribute their share to the assessments of the parish. In the meantime the committee were waiting to hear what the result of the communication with the company would be.

THE INSTITUTION OF CIVIL ENGINEERS.—The following awards, amongst others, have been recently made by the Council :—The Howard Quinquennial Prize to John Percy, M.D., F.R.S., Hon. M. Inst. C.E., in recognition of his researches on the Uses and Properties of Iron. For papers read and discussed at the ordinary meetings during the season 1886-87 :—A Telford Medal and a Telford Premium to John Hopkinson, jun., M.A., D.Sc., F.R.S., M. Inst. C.E., for his paper on "The Electric Lighthouses of Macquarie and of Tino." For papers printed in the *Proceedings* without being discussed :—A Telford Premium to Killingworth William Hedges, M. Inst. C.E., for his paper on "Central-Station Electric Lighting."

THEATRE LIGHTING IN LONDON.—We are pleased to note that the electric lighting of the London theatres is making

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steady progress. Messrs. E. L. Berry and Co. write us on this subject as follows:—"We beg to inform you that Mr. Edwardes, lessee of the Gaiety Theatre, has now also taken the Empire Theatre, and has placed all engineering and electric lighting arrangements in our hands. We have also received instructions from Mr. H. J. Leslie to light up the New Lyric Theatre, in Shaftesbury-avenue, with electric light all over the house, including the stage. The electric light will be extensively used for stage effects, the lime light being entirely dispensed with. All the latest English and foreign improvements will be adopted."

THE LECLANCHÉ BATTERY FOR ELECTRIC LIGHTING.—The Leclanché cell has proved so great a success for telegraphic and domestic use that it is no wonder that attempts should be made from time to time to utilise the same chemical reaction for the production of the heavier currents required for electric lighting. All such attempts have hitherto failed, owing to the rapid polarisation of the cell. The latest suggestion for overcoming this difficulty is due to M. Jarriant, although, unfortunately, we cannot feel *very* hopeful as to the commercial practicability of the idea. M. Jarriant proposes to take four separate batteries, each capable of lighting the required lamp or number of lamps for one minute; he then employs a commutator driven by clockwork to switches on the batteries successively in turn for the time above mentioned. In this way each cell gets a rest for three minutes out of four. The clockwork is made to run for twenty-four hours.

THE LIGHTING OF THE LAW COURTS.—On the occasion of the Jubilee Banquets of the Law Society, which were held in the Great Hall of the New Law Courts on Saturday and Monday last, the hall was lit for the first time by Pilsen arcs, run in parallel with the incandescent lamps in the corridors. The lamps, which are of a recently improved type, were supplied by Messrs. H. F. Joel and Co., and will remain as a portion of the permanent fittings of the hall. We are informed that the "Improved Pilsen" lamps have also been recently supplied by the same company to the Admiralty, to the London University, the Apothecaries' Hall, Victoria Station, and to several mills for use in dye houses. During the banquets above referred to the reception rooms were lit by variegated lamps hung amongst the foliage of the plants. These lamps were supplied by Messrs. Baily and Grundy, who are also supplying some extra machinery for the permanent installation of the Courts.

THE USE OF ELECTRO-DISSOLUTION IN CHEMICAL ANALYSIS.—The *Chemical News* has a paper by Mr. H. N. Warren, describing some results obtained by the use of electricity in chemical analysis:—"By placing iron boride at the positive pole with a platinum plate as the negative pole of a powerful battery, and using dilute sulphuric acid as a solvent, in twelve hours all the iron had dissolved, whilst the boron and other impurities were precipitated. A similar result was obtained with ferrous sulphide, whereas with silicon iron and phosphide of iron, zinc, &c., the silicon and phosphorus respectively were only partially precipitated. In hydrochloric acid copper may be separated from arsenic, iron, zinc, &c., by electro dissolution; and in ammonia, copper, silver, zinc arsenic, and other alloys may be resolved into their constituent metals. Electro-dissolution has also been applied to the preparation of unstable compounds, such as potassium ferrate, &c."

AN ARC LAMP WITH PNEUMATIC REGULATOR.—M. Leibold, of Aix-la-Chapelle, has introduced an arc lamp in which the regulation is effected by the escape of air from a reservoir. The reservoir consists of a pair of circular metal plates, connected all around with thin leather like a pair of bellows or a concertina. The upper carbon holder is attached to the upper plate. A valve in the lower plate permits the reservoir to be filled with air when the upper plate is raised by pulling down a chain to which it is attached. The air can then only escape through a small flexible india rubber tube, and this tube is closed by the pressure of a stiff spring. The spring, however, is connected with the armature of an electromagnet, which is placed in a shunt-circuit; consequently, when the resistance of the arc increases the armature is pulled down, opening the tube and allowing the air to escape until the upper carbon has reached its proper position. The lower carbon is pressed upward by a spring.

RANGE-FINDING BY ELECTRIC LIGHT.—A simple and ingenious plan has been suggested by M. E. Genglaire for enabling an ironclad to determine the range of an object after nightfall. M. Genglaire proposes to mount two powerful projectors, one at the bow and the other at the stern of the vessel, and to converge their beams upon the object in question. Then noting the angles between the right line joining the two foci and the convergent beams, we can solve the triangle and determine the distance of the vertex. It is obvious that the method does not pretend to any great accuracy, but it seems to be capable of sufficiently close approximation for the purpose in view to make it worth while for the Admiralty to try some experiments in this direction. M. Genglaire also suggests that to facilitate the operation the vessel can be brought round until the two angles are equal, or very nearly so, and that reference can then be made to a table of distances previously prepared so as to avoid having to make calculations at the time.

THE ELECTRO-OSTEOTOME.—While the use of electricity as a therapeutic agent is still more or less beclouded by the multitude of quacks which thrive upon the folly of those who pin their faith most firmly to what they least understand, the employment of electricity in surgery is, upon the other hand, rapidly becoming more and more extensive. Electric cautery is now a recognised operation, and the electric laryngoscope is in use in all the hospitals of London. Probably, however, no more valuable application of electricity to surgery has yet been devised than that of the electric osteotome or bone-cutter, which has been introduced by Dr. Roberts, of New York. Operations for diseased bone have hitherto been carried out in certain cases by a process of a most primitive, not to say barbarous, character. Any one wishing to become acquainted with some harrowing details may consult a recent issue of *Health*. Dr. Roberts's instrument, however, effects in a few seconds what the most skilful surgeons have hitherto taken many minutes to perform. It consists of a minute circular saw, which by means of a tiny motor is made to revolve at very high rate of speed. By this means the bone can be cut in any required direction with great ease and rapidity.

THE BELL TELEPHONE PATENT IN THE UNITED STATES. The following paragraph from an American paper will give an idea of the present position of the great telephone patent case, in which the arguments before the United States Supreme Court have recently been concluded:—"There is much speculation among persons interested in the telephone cases as to the time when the decision of the Court in those cases will be rendered. So far as is known the Court has given no intimation of an intention to decide them at the present term. The prevailing impression among lawyers seems to be that if the Court has concluded to affirm the judgment of the lower Court an announcement to that effect will be made before the adjourn-

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ment next week, and that the opinion will be prepared at the leisure of the Court during the summer vacation. If, however, the Court should decide to reverse the judgments it would probably be necessary to prepare the opinion at once for the guidance of the lower tribunals, and it is regarded as doubtful whether the Court has had or will have time enough to prepare an opinion as long and elaborate as that which a reversal would make necessary. In such a case, therefore, the decision would probably not be announced until next term."

An Electrical Exhibition in New York.—At the meeting of the New York Electrical Society, the electrical section of the American Institute, held on May 25th, the project of holding an electrical exhibition in this city next autumn under the auspices of the society was brought forward, and received the hearty approval of the members. This exhibition, which is to be held in the Exhibition Hall of the American Institute, and is intended to include all the applications of electricity, will be the first of its kind that has ever been held in New York. The American Institute has signified its willingness to aid the society in its work in every possible way, and the American Institute of Electrical Engineers has also assured the society of its co-operation and support. It is probable that a course of lectures which is now being organised by the American Institute of Electrical Engineers will be in some way, through the agency of the society, connected with the educational work done at and by the exhibition. The details of the exhibition will shortly be made public, and thus ample time will be afforded for the preparation of intending exhibits. We understand that further information on the subject can be obtained from the president, Mr. J. M. Pendleton, 49, Broadway; Mr. J. Wetzler, secretary, 175, Potter-building; or Mr. C. W. Hull, superintendent of the American Institute, Clinton Hall.

Photographs of Lightning.—The following circular letter has been issued by the Council of the Royal Meteorological Society (whose address is 30, Great George-street, Westminster) and has been forwarded to a large number of amateur and professional photographers throughout the country:—"Sir: The Council of the Royal Meteorological Society are desirous of obtaining photographs of flashes of lightning, as they believe that a great deal of research on this subject can only be pursued by means of the camera. The council would esteem it a great favour if you, or the institution which you represent, could give them any assistance in this matter, either—(1) By sending them copies of any photographs of flashes of lightning that may have been already taken; (2) by endeavouring to procure them yourself: or to interest others in the work. It may perhaps be well to mention that the photography of lightning does not present any particular difficulties. If a rapid plate and an ordinary rapid doublet with full aperture be left uncovereed at night during a thunderstorm for a short time, flashes of lightning will after development be found in some cases to have impressed themselves upon the plate. The only difficulty is the uncertainty whether any particular flash will happen to have been in the field of view. The council hope that now the thunderstorm season is approaching, many photographers may be found willing to take up this interesting branch of their art.—I am, Sir, your obedient servant, William Marriott, assistant secretary."

The Phonograph.—According to an American journal, Mr. Tainter, who has long been associated with Prof. Alexander Graham Bell, of telephone fame, has taken up the Edison phonograph at the point where he left it, and developed it from a toy to an article of commercial value. Before long the new instrument will be placed upon the market. It is constructed on the same principle as the phonograph, but instead of giving out a squeaking, metallic sound, as when the sheet of tin foil was used, it now produces a full, sonorous sound, which can be distinctly heard and understood in any part of an ordinary room. The conversation is recorded upon thin sheets of wax in shape of a tube placed upon a cylinder. One of these little tubes will hold 1,000 words. A merchant who has forty letters to answer can sit before one of these machines, turn the crank, and talk his answers directly into the machine, which records them upon the wax tube in the same manner as in the old phonograph. Afterwards one of these little tubes can be slipped off the cylinder and sent by mail to any part of the country. When received it will only be necessary to put the wax tube into a similar machine, and it will reproduce the words of the original speaker as often as may be wished. The thin wax tubes will be on sale at stationery stores at about the same rate as letter paper. The general employment of the phonograph would be to a certain extent a preventive of forgery, since it reproduces the exact voice of the speaker, so that those who are familiar with it will recognise it at once.

A.D. 1622.—A correspondent of the French journal *Cosmos* states that in a curious old work printed at Paris in 1622 there occurs a remarkable passage, of which the following is a translation:—"We may also tell you this great and wonderful secret, which a certain German has shown to King Henry, and who, by his industry and dexterity, is able to speak and to converse with those who are far away, and this by means of the magnet. He first rubs together two needle magnets, and then places them each separately upon two clock dials, around which are engraven the twenty-four letters of the alphabet. If, then, they wish to speak together, or to make each other understand what they would desire, they move one needle around until it has pointed to the letters which are necessary to make the words and sentences that they would say, and as they turn one needle so also the distant needle turns, making always the same movement. The King seeing this wonderful secret forbade him to divulge it, fearing that thus would be opened very dangerous communications between the armies of his enemies and their besieged towns." The title page of the work in which the above passage is said to occur (on the 247th page) is as follows:—"L'incredulite et mescreance du sortilege plainement convaincue Par P. de l'Ancre, conseillor du Roy en son conseil d'Estat à Paris. Chez Nicolas Bvon, ruë Sainct-Iacques, à l'enseigne Sainct-Claude et de l'Homme Sauuage, MDCXXII." The notion that two magnetic needles by being rubbed together would afterwards move in sympathy finds a place in more than one book of marvels of the 17th century, but the above date is, we believe, the earliest to which it has yet been traced.

Remarkable Atmospheric Phenomenon.—In *Nature* of June 2nd Mr. E. J. Lowe, of Shirentown Hall, near Chepstow, gives the following description of a remarkable atmospheric phenomenon witnessed in his neighbourhood on April 26th, 1887:—"A phenomenon was seen here this even ing quite distinct from anything I have before observed. It was an exact copy of streams of aurora borealis rising from a low arch, but instead of being in the northern heavens it was near the south horizon. The sky was cloudless, except a long thundercloud which extended from near south-south-west to almost south-south-east, the upper portion of this cloud being about 12° above the horizon. From this cloud issued from one to three streams of conspicuous white light, the north-easterly stream being the largest and brightest, and this continued visible from 9:40 until 10:5 (the others were only

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seen for five minutes). The streams were at an angle of about 53°, and moved slowly easterly (the cloud moving in the same direction). The longest stream reached an altitude of 25°, and at 10 o'clock exactly (G.M.T.) the base was immediately over the Avonmouth Lighthouse. The light of the streams was more persistent and less flickering than is usually the case with aurora borealis. There was also a confused luminosity behind the cloud, which varied considerably in brightness; this made the outline of the cloud at one time distinctly visible, and at another scarcely discernible; this also gave the clouds a black appearance. After 10 p.m. other clouds rose above the cumulo-stratus, and the streams became hid. Three hours afterwards there was a snowstorm, and the ground was white till 7 a.m. Reports from Somerset, Dorset, and Devon would be valuable."

SOIRÉE OF THE ROYAL SOCIETY.—On Wednesday evening last, at Burlington House, the Royal Society gave a soirée, at which upwards of five hundred guests attended. The exhibition of electrical experiments and apparatus formed, as usual, one of the most interesting features of the evening. The beautiful phosphorescent effects produced by the electric discharge over rubies, diamonds, and emeralds, were shown on a scale of unusual magnificence, some very fine jewels being lent for the purpose by Mr. Streeter. Dr. Sclater had also sent from the Zoological Gardens a very fine specimen of the electric eel, and some few of the guests were brave enough to pull its tail for the edification of lady friends. The greatest possible interest was also taken in the arrangements made by the United Telephone Company for enabling the guests to listen to the performance of *Ruddigore* at the Savoy. No less than 88 receivers were placed on the circuit, so that although each listener usually secured a pair of telephones, it would have been possible for 88 people to have heard simultaneously. The opera was rendered with excellent effect, and greatly delighted the guests. We may mention in passing that with one exception this is the largest number of telephones that have ever been switched on to a theatre, at any rate in this country. The exception is also to be credited to the United Telephone Company, who once connected 120 receivers between the Bristol Hotel in Bond-street and the Comedy Theatre. In addition to the performance of *Ruddigore*, telephonic music was heard on Wednesday evening from Brighton. In this case an Edison loud-speaking receiver was employed, and a cornet solo performed at Brighton was rendered audible all over the room. Altogether the soirée was one of the most interesting of recent years.

THE VAN DE POELE (OVERHEAD WIRE) SYSTEM OF TRAMCARS.—The following testimonial to the simplicity and efficiency of working a tram line on the overhead conductor system will be read with interest, even though the system is one scarcely likely to come into extended use in this country. In a recent letter to the Van de Poele Company, Judge J. E. Harriman, the President of the Electric Street Railway at Appleton, says:—"Our road, as you know, commenced operating August 16 last; except a few weeks to get the track all right and get the cars limbered up, we had a continuous run. The snow we found we could master, and did with the electric cars, pushing a snow plough which we made ourselves. The overhead wire, which we feared would give us the most trouble, has never bothered us to exceed two hours twice this winter, although the telephone and telegraph wires were made useless for their business many times. We know that we have made more hours and better time all winter than we could possibly have done with animal power. We operate our road three miles, in schedule time, with three cars regularly, and the time does not vary a minute any day at the switches or at the end of the line. We run five cars on busy days. I do not need to elaborate—we cannot find any fault with the system. The wires have not been touched since last fall, and the motors are doing their work perfectly. The travellers are doing well. The dynamo I have not heard from in a long time, although a new man is running it. All of the help that we have are new at the business, yet all runs like a clock. Hundreds have been here to examine our road, and without an exception have been perfectly satisfied that electricity is the future power for street railways on account of its simplicity, reliability, rapidity, and neatness. You may quote our company and our citizens as for it first, last, and all the time."

JARMAN'S ELECTRIC TRAMCAR.—In our issue of October 29th, 1886, we gave some description of a model tramcar, driven by an electro-motor, and constructed by Mr. Jarman. This "system" (of which, so far as it is unique, we expressed our own opinion at the time, somewhat to Mr. Jarman's discontent) has now been placed in operation at Brixton, and we should still be very pleased to hear of its permanent success. There is no reason whatever, so far as we know, why it should not stand a very fair chance of success, if only Mr. Jarman selects a reliable form of storage battery, an efficient motor, and a good mechanical gearing. Our criticism is merely that if these arrangements are reasonably perfect the advantage of duplicating the motor for forward and backward running—which is Mr. Jarman's patent—is not great. The following description appeared in the *Daily News* of June 7th:—"Jarman's self-contained electric tramcar was on view yesterday in Electric-lane, Atlantic-road, Brixton, S.W. The invention shows a marked improvement over previous electric cars, the advantage lying mainly in the fact that two armatures are fitted into the electro-motor instead of one. They are worked alternately on the forward and return journeys, each being thus constantly cooled. The weight of the car itself is 3 tons, and the electro-motor, storage cells, &c., bring the weight up to about 5 tons 6 cwt. The brakes of the car are of a novel description, the brake-wheels being placed upon the axle of the electro-motor. It is believed that the cost of the electricity required to propel the car will not exceed 2½d. to 3d. per mile run. A signal bell is placed at each end of the car, and this bell can be worked by the driver's knee. Yesterday's experiments upon a line with an incline of 1 in 40ft., and including a curve having a 43ft. radius, were highly satisfactory. Considerable speed was attained, the car responding readily to the brake, and its direction was easily reversed."

ELECTRIC LIGHTS IN LABORATORIES.—Mr. H. G. Torrey, of the United States Assay Office, writes to the *New York Engineering and Mining Journal* on the subject of electric lighting in laboratories as follows:—"Sir: A short time ago I learned that one of the prominent smelting companies in this vicinity, in the equipment of its new laboratory, had omitted the incandescent electric light on account of its possible effect upon their balances by magnetising and electrifying them. Although the Edison Company does all its weighing of meter zincs on balances which are close to their electric lights, I thought it might be interesting to some of your readers who are daily using delicate balances, and whose work may be injured by the slightest variation in the instruments employed, to know exactly what effect electric light currents have on delicate weighing. To determine this, experiments were made under my supervision by Mr. Taylor, one of my assistants. Magnetising effects were examined upon balances made by Becker, Troemner, and Oeterling with

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uniformly negative results, and an examination of these balances showed that there was no iron or steel in their construction, with the exception of a minute steel pin at the stirrup and the steel knife edges. With the view of determining what the effect would be were there any considerable masses of iron in the construction, an iron wire about 1½in. long, weighing 200m., was placed on one pan and exactly balanced. The current being passed above this wire and parallel to it, a very slight magnetic effect was produced when the distance did not exceed one-eighth of an inch. As it is impossible to run the conducting wire closer to the balance than six inches, the magnetic effects, even though there be iron in the construction of the balance, are inappreciable. The electrifying effects of static electricity are produced by dynamic electricity only when the potential is very high, and none whatever are noticeable with the very low potential of the incandescent light current."

THE LIGHTING OF THEATRES.—The manager of the Prince of Wales Theatre, which is lit throughout by electric light, writes as follows to the editor of the *Morning Post*:—"Sir: In reading your reports of the terrible calamity which has recently occurred at the Opera Comique in Paris, in aid of the sufferers of which I have arranged to give my theatre for a *matinée* on Wednesday, June 8th, I think it must be allowed that the panic was caused, or at any rate greatly aggravated, by the fact of the theatre being in total darkness, owing to the gas having either gone out or having been turned out, whereas had the electric light been in use, as it is here at the Prince of Wales's and other London theatres, no such terrible result could have happened. In support of this it may interest some of your readers when I tell you that only a few weeks ago, during the performance here of the evening farce, one of the gas bags used in connection with the lime light (which since the evening in question I have entirely dispensed with in the theatre) exploded, the concussion being sufficiently great to put out the gas in the auditorium. All confusion, anxiety, or panic were, however, averted owing to the electric light being in use throughout the theatre, for simultaneously with the explosion the lights not used during the performance were switched on before the audience could realise what had occurred. I went to the footlights, explained what had happened, and ordered the iron curtain to be lowered. Every one remained in his seat, and the performance was continued after some ten or fifteen minutes' delay. Did your space permit I could easily explain how, with timely and proper precautions, such as fire drill for the men, extra and special exits from every part of the house, with doors opening outwards on to the street, only requiring a push from the inside to open them, and with iron doors disconnecting the auditorium from the stage, and the stage from the artists' dressing rooms, as is the case in this theatre, every possible danger of panic or disorder can be avoided both before and behind the curtain."

BRITISH VERSUS AMERICAN MODES OF DOING BUSINESS.—The following anecdote is told by a correspondent of the *Electrical World* of New York. We reproduce the story without any feeling of pride in the matter; but at a time when the conduct of business amongst the electrical engineers of this country is under discussion it will not be amiss to give one more illustration of "the way in which electric light business is lost"—and gained:—"About a year ago the city of Puebla asked for estimates for illuminating its streets by the electric light, and an agreement was entered into between the city and an Englishman for a plant of 100 lights. The contract was drawn up by the city authorities, and they did not seem to think that there was any practical difference in the systems, for there was no particular system named in the contract. The work was not proceeded with in time to permit of having the plant installed at the date required by the contract. This, it is said, was due to a lack of funds on the part of the contractor. A new arrangement was made, however, which gave him until the 15th of March of the present year to carry out the scheme; but still owing, it is said, to lack of funds, the apparatus did not arrive until some time after the 15th of March. In the meantime, the representatives of a leading American company, who had had their eye on Puebla, made an exhibit of their system to the Puebla Government, and succeeded in getting the old contract annulled on the 15th of March, when it was apparent that the other contractor could not install the plant in time. Not only did they get the old contract annulled, but they obtained a new one in their own favour for 125 2,000 candle-power lights to be run by water-power supplied by the falls of the Atoyec River, eight miles from Puebla. According to the estimates made, there will be a very considerable saving by the use of water-power. Coal is so expensive in Mexico that if this were used the cost of the 125 lights would be about 20,000 dollars a year, whereas, by the use of water-power the expense is only 2,000 dollars."

THE LATE THOMAS STEVENSON.—We extract the following from a charming biographical notice of his eminent father by Robert Louis Stevenson, the popular novelist, in the current number of the *Contemporary Review*:—"But the great achievement of his life was, of course, in optics as applied to light-house illumination. Fresnel had done much; Fresnel had settled the fixed light apparatus on a principal that still seems unimprovable, and when Thomas Stevenson stepped in and brought to a comparable perfection the revolving light, a not unnatural jealousy and much painful controversy rose in France. It had its hour; and as I have told already, even in France it has blown by. Had it not it would have mattered the less since all through his life my father continued to justify his claim by fresh advances. New apparatus for lights in new situations was continually being designed with the same unwearied search for perfection, the same nice ingenuity of means; and though that holophotal revolving light perhaps still remains his most elegant contrivance, it is difficult to give it the palm over the much greater condensing system, with its thousand possible modifications. The number and the value of these improvements entitle their author to the name of one of mankind's benefactors. In all parts of the world a safer landfall awaits the mariner. Two things must be said; and first, that Thomas Stevenson was no mathematician. Natural shrewdness, a sentiment of optical laws, and a great intensity of consideration, led him to just conclusions; but to calculate the necessary formulæ for the instruments he had conceived was often beyond him, and he must fall back on the help of others, notably on that of his cousin and lifelong intimate friend, *emeritus* Prof. Swan, of St. Andrew, and his later friend Prof. P. G. Tait. It is a curious enough circumstance, and a great encouragement to others, that a man so ill equipped should have succeeded in one of the most abstract and arduous walks of applied science. The second remark is one that applies to the whole family, and only particularly to Thomas Stevenson from the great number and importance of his inventions; holding, as the Stevensons did, a Government appointment, they regarded this original work as something due already to the nation, and none of them has ever taken out a patent. It is another cause of the comparative obscurity of the name, for a patent not only brings in money, it infallibly spreads reputation; and my father's instruments enter anonymously into a hundred light-rooms, and are passed anonymously over in a hundred reports, where the least considerable patent would stand out and tell its author's story."

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THE FARADAY DISC DYNAMO MACHINE OF JEHL AND RUPP.

An essential disposition of every disc armature dynamo is that a greater or less number of alternating magnet poles are arranged around the circumference of a circle, faced by an equal number of respectively opposite poles. In the space between these two rows of magnetic poles, viz., in the alternating magnetic fields produced by them, revolves the disc armature, which consists of a suitable number of copper bands or coils, likewise arranged around the circumference of a circle.

The electromotive force generated is proportional—

(1) To the area of every armature coil.
(2) To the number of armature coils.
(3) To the intensity of the total magnetic field.
(4) To the number of magnetic poles in one row.
(5) To the speed of the armature.

In all disc dynamos constructed till now there is generally a great number of small electro-magnets whose cores lie parallel to the shaft or axis of the armature. In the dynamo which is about to be described, and which has been designed by Jehl and Rupp, there are, on the contrary, only two magnets of considerable iron mass. Such magnets are far superior to the former. To show this we will compare a magnetic system having four pairs of opposite poles with another system consisting of, say, twelve pairs of opposite magnetic poles, assuming the iron mass and the magnetising powers (ampere turns) to be the same in both cases.

In the first case each coil of the armature passes through four alternating magnetic fields in one revolution, whereas in the second case it passes through twelve alternating fields. Of course, if the intensity of the field produced by two opposite poles were the same in both cases, the electromotive force produced by the second arrangement would be three times greater than that produced by the first arrangement.

But now the single magnets in the first case being three times greater than in the second, the intensity of the field produced by two such opposite single magnets is in the former far more than three times the intensity in the latter, for, as it is well known, the magnetic capacity of the same mass of iron is far more useful in a single piece than if divided in smaller pieces, to say nothing of the difference of weight of copper it takes to wind the two systems.

There is also another loss of magnetism in nearly all disc machines, and this is due to the close parallel position of each two adjacent magnet cores—that is, the lines of force commence to jump from one core to the other, being dense at the poles and gradually becoming less dense as we approach the neutral point. These lines are entirely useless, and therefore lost, as the armature does not cut through them. The lines that pass directly from one pole to another and are cut by the armature are called the useful lines, and the ratio of the useful and lost lines determines the efficiency of the magnet. Bollmann, in his disc machine, has tried to enlarge the capacity of his magnetic system (he has a large number of small electro-magnets) by short-cutting or overbridging the magnetic poles in a peculiar manner. But he applies that principle (from my point of view) in an entirely wrong way. Firstly, by his arrangement he gets all north poles on one side of the armature and all south poles on the other side. His electromotive force is therefore only caused by the approach and removal of the armature coils in such places where the intensity of a single magnetic field becomes greater or less, and this electromotive force must necessarily be less than if, under the same circumstances, the field were alternating. Also there is some loss due to the winding of the magnets in such systems where several cores are wound separately but to give the same polarity. We see in such cases where two such cores with their windings are parallel to each other, the current in the adjacent coils passes in opposite directions, and so tends to produce neutralisation of the magnetising force. Now Jehl and Rupp have designed a system of electro-magnets which are free from all the defects mentioned above. In Fig. 1 we see that they have taken four poles. The north poles are diagonally opposite one another, and so also are the south poles. Fig. 1 shows only one half of the magnetic system, there being two such squares between which the armature revolves. It will be seen that the cores lie parallel to the plane of the armature, and at right angles to the axis, and not parallel to the latter, as in other machines. Of course, it is understood that a north pole on one side faces a south pole on the other, and thus the fields become alternating. It will be seen that such a system contains a large mass of iron, and will produce a very strong, dense, and alternating magnetic field. Such a system has very little magnetic resistance. Then, again, we see that the loss of lines of force in the machines spoken of above is here entirely avoided. The armature turns between the two squares forming the magnetic system and the lines of force commencing from a dense positive direction grow thinner just to the neutral point, where they assume a negative direction, gradually becoming denser till the densest part is reached, and then again becoming weaker to the neutral point, and so on. All these lines are always cut by the armature, so that all lines which pass from one square to another must necessarily come in the path of the armature. Thus by such a disposition four magnetic fields with large area and great strength is obtained. Another advantage of such a magnetic system is that all parts of the cores are effective, and wire wound from one pole-piece to the other; there being no yoke, which is a general thing in other machines, only serves for the conduction of the lines of force, and is not generally serviceable for their generation. It will, however, be shown later that some modification of this system has been introduced, with the advantage of saving copper in the field.

The Armature.—In all disc machines till now constructed the armature is built up of copper bands, either in a zig-zag form around the centre of the armature or consisting of coils placed together around the centre. In both these cases there exists always a considerable space where there is no copper; or if in the latter case the single coils are made of many turns, each becoming gradually smaller, it is evident that the electromotive force due to some of these additional turns is almost insignificant in comparison to the increase of resistance due to these additional coils or turns. Jehl and Rupp have succeeded in constructing an armature where all space inside the outer circumference is occupied by copper, and in which each and every coil or turn has the same area. This fact will be shown later on. They take a strip of copper, as shown in Fig. 2, which has a cut, say of 1 5 mm. in thickness, and terminating to about 40 mm. from one end. At this end, and on both sides of this strip, are incisions which serve the purpose of holding these pieces of copper to the shaft, by means of two plates, which have at their outer circumference flanges which fit into the incisions. It is evident that instead of incisions we may have projections, as shown by the dotted lines in Figs. 2 and 3. They then take this strip, and put it in a form, and press it into a shape somewhat as shown in Fig. 4. Fig. 4 shows, however, only one-half of one turn and three-fourths of another, showing also how one turn is connected to the other. It is evident, therefore, that each coil fits into one another, and the connections are made at the outer circumference by means of small caps, as shown in Fig. 4. It will be seen from this construction that every coil has the same area, and each and every coil is so divided that one-half is in the inside its neighbouring turn, while its other half is on the outside of this neighbouring turn; also that one-half of every turn is on one side of the armature, while its other half is on the other side. We can then place one turn inside the other until we complete the armature. Of course it is understood each turn is insulated from the others. It must be understood that this construction is not a simple mutual overlapping of coils, which would cause an oblique or sloping position of the coils, but is a mode by which each half of the coil lies in a different yet parallel plane, and between these two planes is placed some insulating material. Fig. 9 shows about one-fourth of the armature, *a* is the part of a coil to which the commutator bar is connected, *b* is the part where the flanges of the plates that are attached to the shaft rests—(these plates and shaft are not shown), *c* is a ring of

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wood with teeth, which teeth pass into the space between each connecting cup *d*, while on the top of this ring wire is wound to hold or bind all together.

Again, consider a single turn or coil of the armature, as shown in Fig. 4. This coil or turn can be made from a strip of copper, as already shown. If, however, we saw or make a strip of copper as in Fig. 3 we can form several from one piece. The advantage of this is that it saves soldering. However, in practice it will be found more convenient to make them from a single strip, as in Fig. 2.

Fig. 1

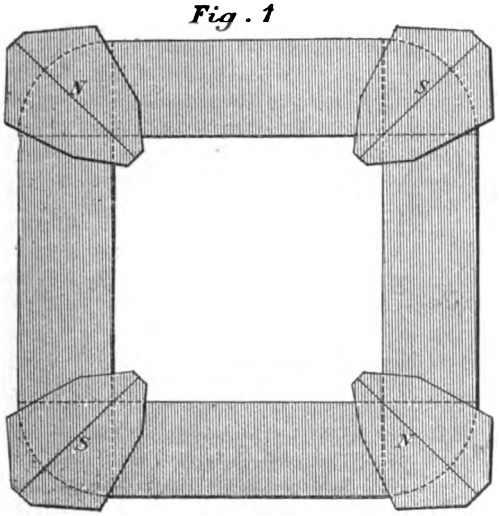

Fig. 2

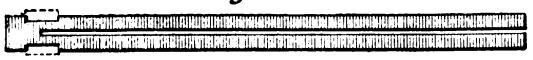

Fig. 3

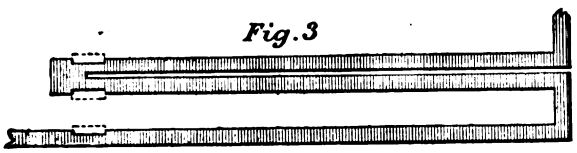

Fig. 4

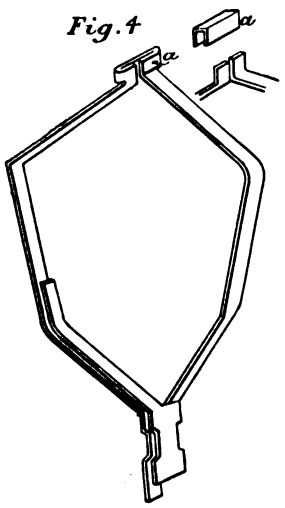

Fig. 5

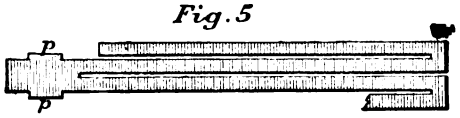

Fig. 6

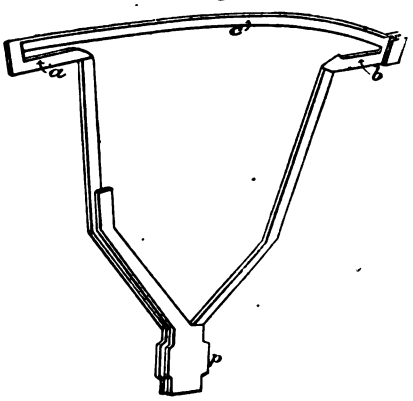

Fig. 7

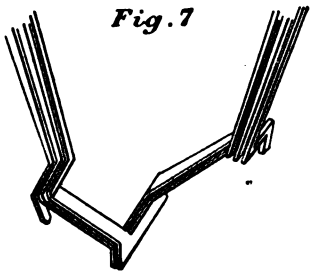

Fig. 10

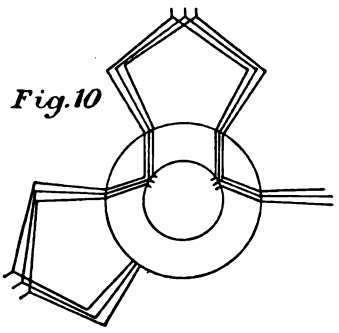

Fig. 8

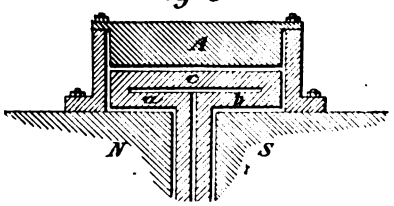

Fig. 6 shows another form of a turn, differing somewhat in shape from Fig. 4, but in principle the same. This is a very good arrangement, as the surface or area is somewhat larger than in Fig. 4. To make such a coil, we take a strip of copper and cut it as shown in Fig. 5. It will be seen that instead of incisions it has projections, P, which fit into a groove in the plate attached to the shaft. These projections P have the advantage that the area of that part of the turn or coil is increased instead of diminished, as is the case with the incisions, and thus that part is not apt to heat; its disadvantage, on the other hand, is that there is some waste of copper when constructing such a form, while when making it with the incisions the copper is nearly all utilised, with the exception of that little space where the incisions are cut. It will be noticed that in Fig. 6 the top part of the turn makes connection from the right-hand arm *a* to the left-hand arm *b*. This top part, *c*, is the connecting band that makes connection with one turn to its neighbour—that is, it forms part of one turn, and its end is soldered on to the next. Supposing we are looking at the armature from the front—that is, looking at right angles to the shaft—we will have a view as shown in Fig. 8, where *a* and *b* are the right and left hand arms, while *c* is the top connecting band. N and S are the two poles, while if we place a piece of iron A in the position as shown in the drawing, lines of force are drawn over in that direction, and the top parts of the turns therefore cut them.

It is evident that the number of coils in an armature depends upon the inner circle. This inner circle can be entirely filled up with copper, while going away from it space

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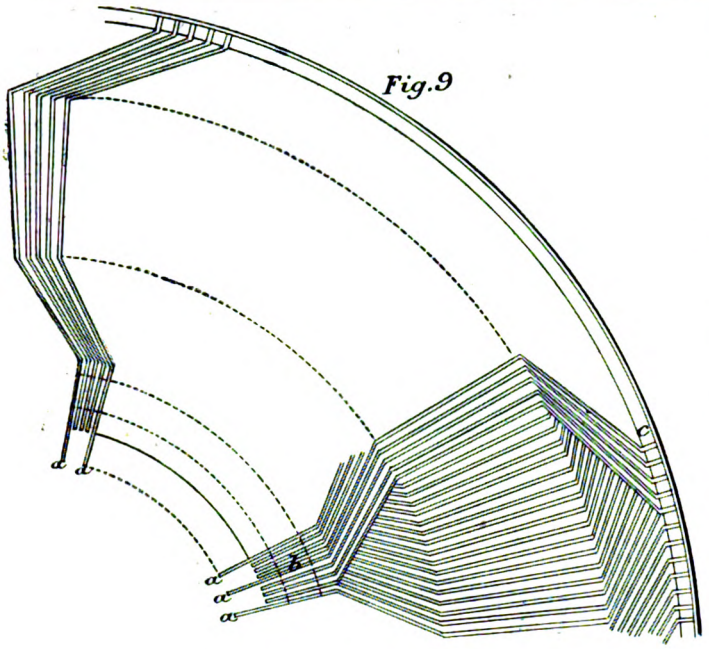

Fig. 9

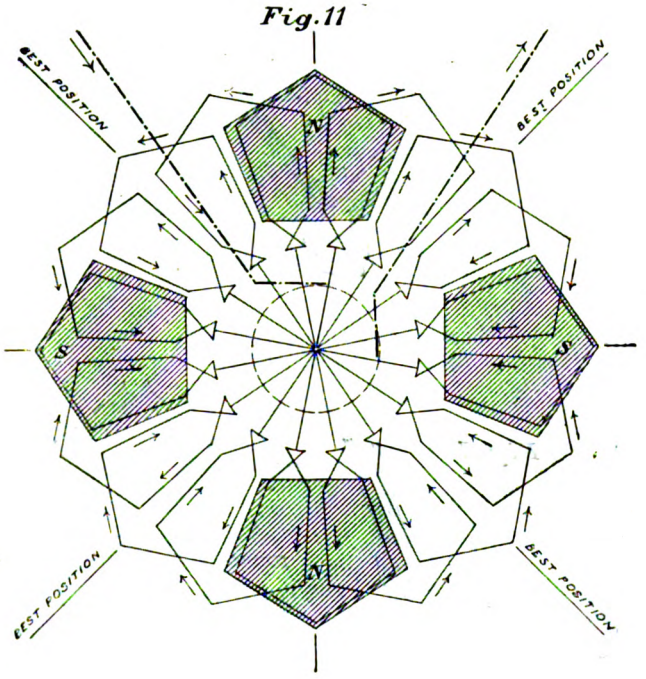

Fig. 11

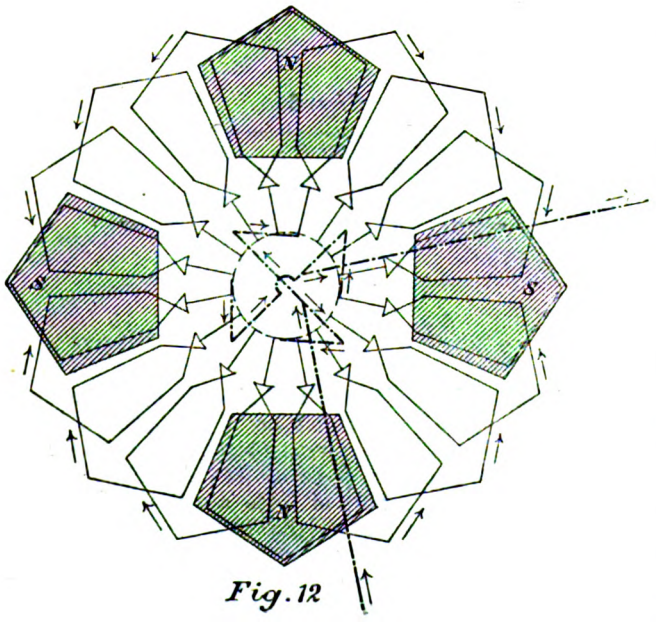

Fig. 12

begins to form. This is got over by making the lower parts thinner but broader than the upper. Thus the section of the copper is not altered, but these parts being thinner admit more coils to be placed upon, or rather around, the inner circle. This arrangement is shown in Fig. 7.

It may be mentioned that this principle of Jehl and Rupp of dividing every turn in two halves, which lie in different yet parallel planes, as already described above, can also with advantage be used in building an armature in the zigzag form, so that all space within the outer circumference is filled up. Fig. 10 shows this converting of coils into this zigzag form.

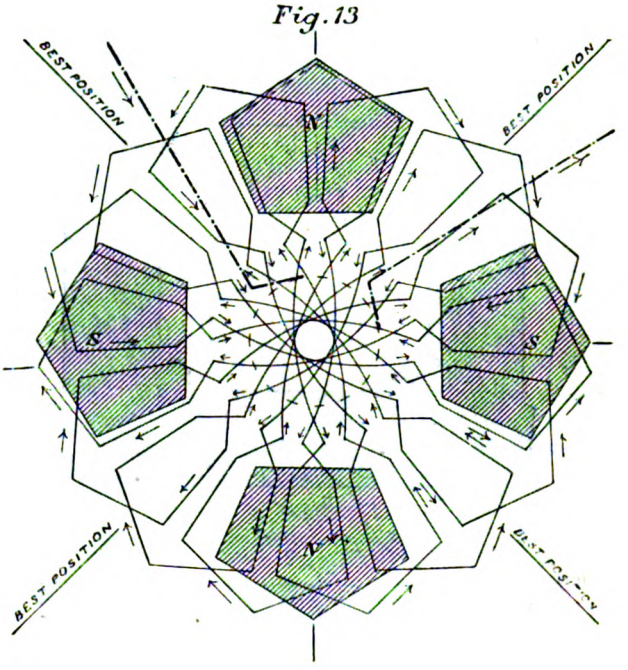

Fig. 13

To gather the currents induced in the coils, there are different ways depending on the number of coils in the armature. If, for example, we have a number which can be divided by four, we can connect them as shown in Figs. 11 or 12, both

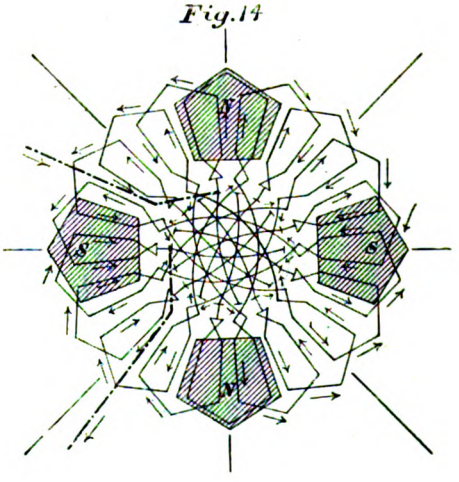

Fig. 14

of which in principle are about the same. In Fig. 11 the commutator blocks, which are diametrically opposite each other, are connected together by putting every pair of opposite coils in multiple arc, thus giving for the whole machine double the current and half the electromotive force.

If we have an odd number of coils the connections are made as shown by Fig. 13. This way puts all coils in series, and thus we get double the electromotive force and half the current.

Then, again, if we have such a number of coils as can be divided by two but not by four, the connections are made as

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shown in Fig. 14. This is an entirely novel way. The coils are also all in series, and yet all the commutator bars diametrically opposite each other are connected together, and on one side the bars appear to be without connection with the coils.

However, when the brush touches that block it collects the current of the coil which is attached to the opposite block. Of course, in all cases described the number of commutator blocks must be equal to that of the coils in the armature.

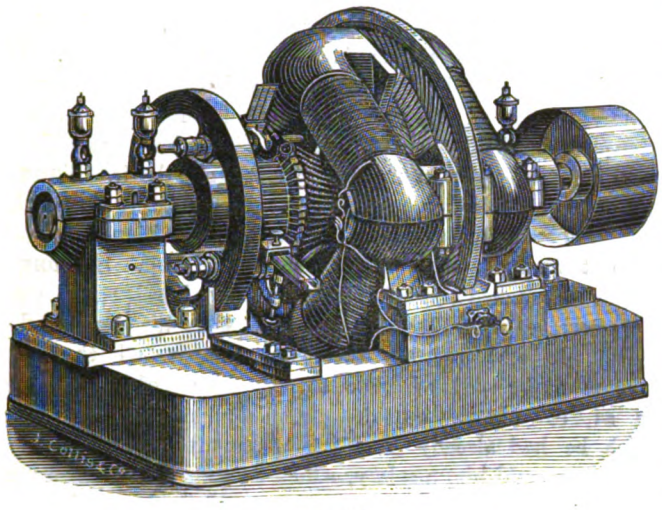

Fig. 15.

Fig. 15 shows the disc machine complete, and which size is capable of giving 350 amperes and 110 volts, using about 5 per cent. for the field-magnets and running at 735 revolutions per minute. The copper in the armature weighs about 24 kilogrammes. The machine is 80 centimetres high and 130

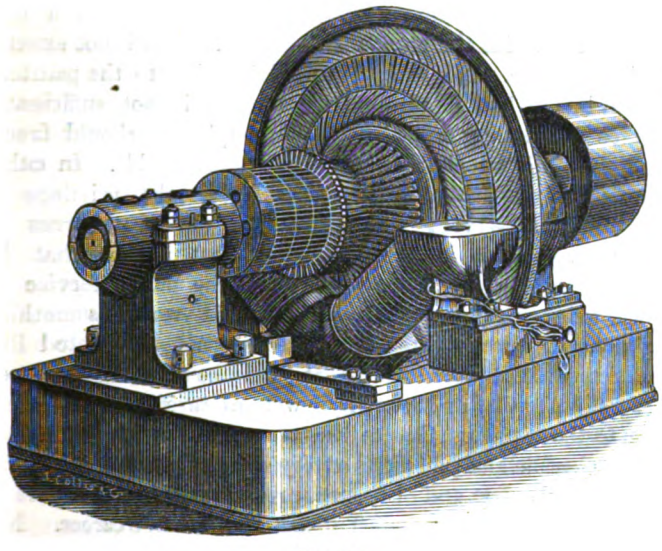

Fig. 16.

centimetres long. Fig. 16 shows the same machine with a fourth of its magnetic system taken off so as to get a better view of the armature, &c. E. D. F.

New Method of Making Porous Earthenware.—A new method of making porous earthenware has lately been used very successfully in Germany. The clay is tempered and worked to the proper consistency with a mixture of water and naphthaline. The objects, after being formed, are placed in a dry kiln and gradually heated until the naphtha is all expelled, leaving the object perfectly and uniformly porous. The dry kilns are so built that all the naphthaline is drawn off and con densed, so that it can be used over again.

"VISUAL SYNCHRONISM."

The visual appearance of the paragraph quoted below, taken from a recent number of an American journal, will doubtless synchronise in the mind of the enlightened reader with feelings of a somewhat mixed character; for unhappily, we fear, that the profound admiration which all must feel for the man who has at last obtained a practical solution of the problem of "seeing by electricity" will get so mixed up with the dazzling vision of ten thousand per cent. "in a short time," that Mr. Rogers's fame as a man of science will be obscured. This would be so sad that we are inclined to recommend our readers to be content for the time being with mastering the scientific aspect of "visual synchronism," and to allow the Yankees to reap the promised pecuniary harvest. We are, however, sorry that for the present our information upon the subject does not extend beyond the following paragraph:—A special despatch from Washington says:—"J. Harris Rogers has published a pamphlet describing a new invention of his entitled 'Visual Synchronism.' Mr. Rogers asks for $100,000 to organise a company to work the patent, and promises a return of $100 for $1 on the investment in a short time. As to the practical applications of 'visual synchronism' he says:—'It enables one in effect, though not in reality, to see by electricity any number of revolving wheels, or moving mechanism, thousands of miles away, so that absolute harmony, or synchronism, is preserved to them all. Of course, many applications of the new system may be made, wherever wheels or moving mechanism may be utilised in telegraphy, electric locomotion, horology, printing, &c. The new synchronism may now be seen by any one, as absolute, and working perfectly for all practical purposes, at an almost incredible velocity. It solves the greatest problem of electrical communication, and will render messages so cheap, it is predicted, that all Governments must adopt it, and ultimately send their letters by wire instead of rail.' Mr. Rogers believes that by this system he will be able to transmit photographs, landscapes, and handwriting by electricity."

In conclusion Mr. Rogers waxes eloquent. He says:—"Capital is invited; but statesmen, of the high-stepping variety, who expect to get control of the patent by promising their great names to float the stock, while conspiring to pocket money without risking their august names on the stock promised, 'need not apply.' We want honest business men. A plague upon greatness. If my earlier patents got mixed up against my will by statesmen, with a Government job, the present enterprise should not be confounded with their failures, for I trusted them in good faith. No one should blame me for having selected them, and visual synchronism, not being encumbered by their names, should not be tainted by their follies. It appeals confidently to science and practical knowledge for success."

Whatever may be the meaning of this pathetic reference to "my earlier patents," we at least join heartily with Mr. Rogers in his disgust at the "great men" who "conspire to pocket money" out of the devices of the poor but honest inventor, and then leave him "tainted with their follies." 'Tis a sad story, though doubtless only half told.

Signalling by Electric Light in the French Navy.—During the recent manœuvres of the French fleet in the Mediterranean signals were transmitted at night by means of incandescent lamps strung from the yard arms of the vessels, and which were lit up or extinguished by a make-and-break key manipulated from the quarter deck. For the transmission of messages by the Morse code a single lamp is of course sufficient, but naval signals must in many cases be capable of prolonged display. To meet this requirement a row of ten lamps is arranged, and the signals are made by sending current through any one or more lamps. The system was found to give satisfactory results.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE ETHICS OF OFFICIAL APPOINTMENTS.

Of the many choice additions to English literature that are credited to the pen of Mr. ROBERT LOUIS STEVENSON not the least will be counted the charming little biographical sketch of THOMAS STEVENSON, his father, in this month's *Contemporary Review*. Elsewhere we have reprinted a short extract from the paper relating to that sphere of STEVENSON'S activities, namely, Lighthouse Illumination, more particularly interesting to our readers. But it is interesting also from a point of view which has less to do with his high merits as an inventor than with his high morality as a man. A filial enthusiasm which no one will think at all overstrained impels Mr. R. L. STEVENSON to claim for his father the distinction of being a public benefactor, in that he spent a long life in successfully combating with the difficulties and dangers of coast navigation, and was the means of surrounding the mariner's perilous career with conditions of confidence and safety. Not unnaturally, the comparatively little known work of his father is a distressing fact to the son, and in dwelling upon the magnitude of THOMAS STEVENSON'S services to his country he offers an explanation of the causes which have prevented his father's name being honoured, as it deserves to be, by the outside world—that is to say, by the general public, who, as a rule, are as prodigal in their acknowledgements of such labours as the most exacting spirit can desire. But the general public did not know of these labours; and a loving son, jealous of his father's reputation, supplies us with the reason. His father was a public officer, an expert paid by the Government, and he never took out a patent. Thus it happens that while his inventions are in hundreds of places where the public see them, his name never appears there. Mr. R. L. STEVENSON makes no complaint on this account, merely insisting on the credit where there has been failure to record it; but he does incidentally observe that whereas the patentee of perhaps some insignificant improvement gets blazoned all over the world, the self-denying and incessant devotion of a whole life may pass away unnamed and unacknowledged if the man, as in the case of THOMAS STEVENSON, besides being a hardworking public servant, happens to be too conscientious to establish his claims through the Patent Office.

Mr. STEVENSON affirms this not only of his father but of the family of the STEVENSONS, who, holding Government appointments, regarded their original work as something due already to the nation, and none of them has ever taken out a patent. We wish that the example of this famous band of workers were more generally followed, and that the morbid sensitiveness of conscience with which the son tells us his father was afflicted were a little more common than it actually is. THOMAS appears to have had some qualms even in respect to the mathematical help he had sometimes to obtain from friends in working out formulæ that were beyond his ken. Seemingly, he half reproached himself for receiving pay in respect to work every scrap of which he had not done with his own hand or brain. It surprises us, therefore, not at all that such a man never did violence to his ideas of integrity so far as to obtain outside pecuniary reward for work which he had already received payment for performing. The nation paid him a salary, which he accepted in full for his services; to have taken out a patent would, in his estimation, have been to seek to make the nation pay him twice over. This conception of his obligation, we are now reminded by his son, cost him not only the sacrifice of money but of fame, which some men value—and, perhaps, rightly value—more than money. One man may contrive and equip a beacon which shall be the means of saving countless lives to the end of time, but his name may be never remembered; while another man shall hand his own down to posterity for having concocted a new paint with which the beacon is decorated. This is not exactly as it should be. No exception need be taken to the painter's brass label; but if the builder himself is not sufficiently brazen in asserting his identity, his employers should freely and gratefully supply what his modesty withholds. In other words, when public departments enjoy the privilege of possessing a servant who places his whole resources at their disposal, it is their duty at least to see that he suffers nothing by having preferred the public service to his own personal speculations. Fame is worth something as a moral incentive; and as all men are not constituted like the STEVENSONS the Government would be none the less well served, but probably better, if it were as careful to pay attention to the sentimental as to the pecuniary side of its bargain with scientific and ingenious *employés*.

This is the first and obvious suggestion which arises out of the consideration of the late THOMAS STEVENSON'S career. Not every eminent inventor has the good fortune to have a son famous in letters who can write his biography after him; and the employers could very easily supply the deficiency at a trifling cost. Every invention should bear the inventor's name, whether patented or not—especially when not; and if this is true of inventions generally it is especially due to inventors who are public servants and have foregone the rights of patentees. But there are reflections of a more general character, with which Mr. R. L. STEVENSON, of course, has no concern, but which we have long desired to give expression to, and gladly take advantage of the present occasion for discussing. We are not at all satisfied with the ethics of the public service in relation to patented inventions. It seems to us that the STEVENSONS were entirely right in their estimate of public duty; and although we are far from

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asserting that the opposite course is in all cases morally wrong, we do think that a public department has it in its power to make such cases wholly indefensible, so that the conduct of these Scottish inventors shall not be the exception but the rule. First, as we have already remarked, there should be a frank recognition of the title to posthumous distinction; but, secondly, the remuneration in lifetime should be on a high scale—high enough, that is, to allow of no excuse for coveting the rewards which a patented invention yields outside the public service. These conditions being complied with, we have no hesitation in saying that a public or *quasi*-public servant who takes out a patent for an invention associated in any way with his profession is guilty of an immoral act. Individual cases might still deserve special consideration on their merits; but, broadly speaking, a servant of the public adequately rewarded for his services out of the taxes of the country has no business to tax it afresh at his own assessment.

Does the reader require to be informed that examples of laxity in this respect on the part of public servants are not far to seek? He may find them in almost every public department. In some of these it is hard to say which is most to blame, the inventor for his greed, or his employers for their stinginess; but in others the inventor is flagrantly in the wrong, and has no excuse but for the general laxity of usage which condones his conduct. Heads of the scientific branches of various Government departments are known to have made large sums of money by inventions or discoveries which ought to be, on strict moral principles, the sole property of the several departments, or, what is practically the same thing, the property of the nation, but which have been appropriated by the individuals under the protection of the Patent Laws. Nominal prohibitions notwithstanding, the thing is done with impunity; and, it is only fair to add, sometimes because the department will not recognise as it ought the pecuniary value of an invention, claiming it unfairly at the price of ordinary wages. But sometimes the case comes under a quite different head. Professors are engaged in the cause of public instruction at salaries which are apparently considered to be inadequate. They are supplied at the public expense with costly laboratories and appliances which could never have been at their disposal but for the appointments. Possessed of these exceptional advantages they make discoveries and perfect inventions which nobody else has a chance of rivalling, and for which they straightway take out patents. This may be quite legitimate as arising out of the original bargain. But surely it is absurd to appeal to the public for funds under such conditions as these. If the public subscribe, the public have a right to the untaxed fruits of their liberality; but to this end they must see that the professors are thoroughly well paid. They ought not to be asked to endow a splendid laboratory, for example, in order that Professor X. or Doctor Y. may invent something worth patenting to eke out his salary, and they should take care that he is relieved from that temptation. Not long ago a scheme was mooted for endowing a national institute for Scientific Research. Before such a proposal can be seriously discussed in this country we must have some assurance that the scientists will recognise their own obligations in the matter, and waive all pretence of right to patent what their researching may find. If a healthier moral tone, more akin to that of the renowned STEVENSON family, prevailed among our public scientific men there would be no need to suggest this precautionary condition; but in these days a lofty standard of rectitude is by no means universal in the scientific world, and, we rather suspect, is too generally regarded as a quixotic or morbid eccentricity.

CORRESPONDENCE.

EDWARD DAVY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of 15th April last Mr. Wilson describes an automatic accumulator switch, the diagram of which looks like one devised more than fifty years ago by Edward Davy for a similar purpose. It is figured and described on page 393 of my "History of Electric Telegraphy" (Spon, 1884).

In your leading article of July 7, 1883, you said:—"One cannot help feeling, as we read the highly suggestive notes and confident anticipations with which his (Davy's) memoranda and letters are crowded, that had he remained in England to steer the destinies of the electric telegraph, it would have made more progress than in other hands it actually did make. What he accomplished was clearly the outcome of his own original mind; and what he predicted as possible, but allowed to be fulfilled by somebody else, belongs to him also."

Is Mr. Wilson another of Edward Davy's numerous debtors?

In this the jubilee year of the electric telegraph we ought not to be unmindful of the claims of those who have lived along the line.—Yours, &c., J. J. FAHIE.

Teheran, Persia, May 9, 1887.

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the important discussion which is proceeding in your columns on the framing of estimates for electric lighting, while refraining for the present from expressing any definite views on the subject as a whole, I would fully endorse the opinion of Messrs. Anderson and Munro that electrical engineers should adopt some definite standard of illumination for a given space, and unless otherwise specified it should be understood that all estimates are drawn up on this basis. The following table, which is taken from the results of a large number of installations, principally in France and Germany, might serve as the basis of such a standard:—

INDOOR ILLUMINATION (floor space lit by each 16 candle-power lamp).

Height of lamp. ft.	Space. sq. ft.	Height of lamp. ft.	Space. sq. ft.
6·5	86	13	62
8·2	75	14·5	60
9 8	66	18	58
11·5	64	20	56

Halls, factories, &c., for each 500 candle-power arc about 1,600 square feet may be taken. For markets, railway stations, &c., for each 800 candle-power arc, 5,000 to 6,500 square feet; and for out of door illumination, streets and open spaces, for each 800 candle-power arc 13,000 to 16,000 square feet may be taken.—Yours, &c., PLONMEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last week's issue Messrs. Anderson and Munro, in the latter part of their letter, refer to a subject which I do not consider has anything to do with the matter. However, they might have stated that along with their letter to the General Manager of the North British Railway Company they enclosed a specification, in which the certain sum named amounted to several hundred pounds, and which they stated in their second method was for purchase of accumulators, from which I inferred that the latter were to be used for lighting the carriages. In the contact system which I patented, as already described in your columns, the current is supplied direct to each individual carriage, from a self-regulating dynamo, by means of a centre rail and contact pulleys.

Although 8 trains, or 64 carriages, have been fitted up and are running daily, it has taken six months to do this, as they were only done gradually, as they came from the repair shops, while only one man is employed in the work.

A little consideration would also have shown that the material used is not manufactured by Messrs. Anderson and Munro, as it comprises chiefly contact pulleys of crucible steel,

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Edison-Swan lamps and holders, white enamel reflectors of malleable iron, and glass globes, &c. Their offer was submitted to me at the time, but I do not seem to have had the knowledge of an intelligent electrical workman, as I could not see how a 4 or 5 compartment carriage, with two lamps in each, could be fitted up in a workmanlike manner, with the necessary wires, lamps, holders, reflectors, globes, &c., for the sum of £4.—Yours, &c., THOMAS CARSWELL, Assistant Engineer, North British Railway.

Edinburgh, June 8th, 1887.

REGULATION OF SERIES TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The interesting notices of Messrs. Sharp and Kent's regulation of series transformers do not contain any actual practical results of careful tests to ascertain the losses in the "choking coils." The figures in the fifth column are calculated from C^2R, which is not applicable in the case of a choking coil. These figures obtained thus are no doubt nearly correct, and the difference between these figures and the correct figures may be too small for consideration when only one coil is employed; but in a distribution system where perhaps 1,000 coils might be in use a small difference in each becomes a large difference on the whole number, and would materially affect the economy.

The opposition to the current which a rapidly alternating E.M.F. tends to send through a choking coil is made up of three factors:—

First. Ohmic resistance.

Second. Apparent resistance, due to rapidity of alternations preventing the current from reaching a steady value distribution over the section of the conductor. This apparent resistance is the same for a wire wound into a coil, laid out straight, or bent back on itself.

Third. "Impedence" due to self-induction, or, rather, the induction of the convolutions of the coils of wire on each other, the value of which depends on the shape of the coil and also on the form, size, and quality of the core of iron upon which choking coils are always wound.

This core in all coils becomes hot, proving that currents are generated in it. By excessive lamination or subdivision this heating can be reduced to a minimum; but still it is always there, and the energy expended in heating this core cannot be found, and is not accounted for by the C^2R formula.

In a transformer $C^2R + C_s^2R_s$ gives the energy expended in the transformer conductors and secondary circuit, where C is primary current and R primary ohmic resistance, C_s secondary current and R_s secondary resistance, including lamps, lead, &c.; but to find the total energy expended we must find the energy expended in the core in addition to the above. We cannot measure the C and R in the core, but we can measure the energy expended in it by measuring the heat generated per minute or hour in it. In an actual test of this kind, with a pressure of 1,200 volts, a resistance in the coil of 5 ohms, a current of 0·18 ampere was found, while the total energy measured in heat was equivalent to over 270 watts, a figure agreeing neither with C^2R nor $E \times C$. A similar result was published by Messrs. Zipernowski and Co., who found nearly 400 watts expended in a resistance under 5 ohms with a current of 0·17 amp., the pressure being over 1,900 volts.

Until we get methods of measuring alternating pressures and currents, calculations like the tables given are not to be taken as anything but approximations.

Mr. Elihu Thomson and Messrs. Sharp and Kent may refer to a patent of Dr. Hopkinson, dated 1881, No. 3362, and to various works by Gordon for early applications of choking coils in place of resistances and in place of lamps.

I referred to Dr. Hopkinson's coils in a letter to the *Electrical Review* of 1883, and mentioned their great value as not absorbing energy like ordinary resistances. Sir William Thomson pointed out their value to me as regulators early in that year, and instanced Dr. Hopkinson's work in a conversation which I had the honour to be present at, the subject being induction coils and self-induction.

Lastly, I may be permitted to express an opinion that to say a transformer is *series wound* is somewhat unmeaning; all transformers known to me are wound alike, whether placed in series order or parallel order in the main supply conductors. The difference between a series transformer and a parallel transformer lies in the section and length of the wires, not in the winding. In a parallel transformer the primary wire is always longer and thinner than the secondary; the same may be the case in a series transformer, but oftener the reverse will be found to be the case. Series transformer or parallel transformer is better; or current transformer and potential transformer might do.—Yours, &c., RANKIN KENNEDY.

THE LIGHTING OF TURIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must ask you to allow me to trespass upon your valuable space, as Mr. J.W. Lieb's letter in your issue of the 3rd inst. is calculated still further to mislead.

The real facts connected with the Turin installation will be found in the accompanying translation of a letter addressed by Mr. Gaulard to the Syndic of Turin at the moment when the circumstances referred to by Mr. Lieb occurred.—Yours, &c.,

T. E. PICKERING, secretary.

(*Translation.*)

To the Syndic of Turin.

Turin, 28th January, 1887.

Sir: The letter you did me the honour to write me on the 27th January infers that the municipal commission would wish to hold the National Company responsible for the defects in the cable laid by Messrs. Bellani Bros, or for the accidents that might happen to that cable during the working of the apparatus.

I did not believe that such an opinion could be expressed by the commission after the conference I had the honour to have with its members on Monday, the 17th inst, but as it is otherwise I will reply by stating, firstly, that the contract with Messrs. Bellani Brothers stipulates our right of absolute control over the installation carried out by them, and consequently the power to reject any defective portion of the installation. I will add further that, in the present instance, I challenge all electricians to justify the possibility of altering any cable by the fact of cutting out of circuit one or several apparatus fed in derivation by this cable. Be this as it may, I think it indispensable to recall here the respective positions of the Turin municipality and Messrs. Gaulard and Gibbs, with the mutual obligations resulting therefrom.

In 1884 the Italian Government set a great example to the other European nations by initiating the institution of an international competition for the greatest advance realised in the transport of electrical energy over a long distance, and at the instigation of its capable and esteemed syndic, the Count de Sambuy, the City of Turin was associated in the scheme.

The success of the experiments made between Turin and Lanse by means of the Gaulard and Gibbs secondary generators has given to the city of Turin an important place in the history of industrial science.

Following upon these facts, the Count de Sambuy, by his powerful and kindly assistance, obtained from the Municipal Council their decision to employ the Gaulard-Gibbs system for the electric lighting of a part of the city of Turin.

To realise the wishes of the Municipal Council, Messrs. Gaulard and Gibbs were obliged to grant the right to represent them in Italy to capatilists to act as their substitutes as regards the municipality of Turin. At the present time, however, Messrs. Bellani Bros, instead of defending the interests of Messrs. Gaulard and Gibbs, have opposed them by supporting infringers, substituting Zipernowski, Déri, and Blathy apparatus for those of Messrs. Gaulard and Gibbs, under the pretext that the apparatus of the latter are imperfect. Under these circumstances I have requested the syndic to be good enough to instruct the Municipal Commission to verify the perfect working condition of my apparatus, insisting on this point—that the working may be verified on the spot, and without using the underground cable. I took this step in the loyal intention of relieving the municipality of all responsibility in the legal proceedings which we must necessarily take against Messrs. Bellani, but the municipality cannot lose sight of the moral and material

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prejudice it would cause to the Gaulard-Gibbs system by not ordering this verification, and the consequent heavy responsibility to which it would be rendered liable.—Yours, &c.,

(Signed) L. Gaulard.

[Now that both sides have placed their version of the facts on record, we think that this correspondence should close.—Ed. *E.*]

MAGNETISM AND GRAVITATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: My attention has been called to the *Chemical News* of June 3, which contains a paper read by Prof. Crookes at the meeting of the Royal Society, on June 1.

In his paper Mr. Crookes criticised a paper published in the *Scientific Journal* of Dax, by M. Thore, and attempted to explain, but ineffectually as he admits, the rotations of M. Thore's cylinders as owing to the influence of radiant heat.

As I have been conducting a series of experiments during the last 18 months of a somewhat similar character, and have rotated a copper and other spheres under the influence of a single magnetic pole, I shall be obliged by your finding me space in *The Electrician* for the publication of my experiments; more especially as I found that when a copper sphere was suspended and acted upon by a magnetic pole *the approach of the human body alone* was productive of a certain degree of axial rotation in the suspended sphere.

At the recent *conversazione* of the Royal Society, held on May 11th, I exhibited the axial rotation of a copper sphere as described above, but without showing the influence which the human body exerted upon the movements.

I believe this and similar experiments which prove the cause of the rotation sweep away the theory that magnetism is nothing more than a definite molecular polarisation, and demonstrate the existence of a current force, for without such a force the slow continuous rotation of the sphere could not be obtained.

I obtained the phenomenon of the rotation of the sphere as described above by a careful study of magnetism which I was induced to make owing to some physiological investigations in which I had been engaged for many years past into the nature of the force by which animal life is sustained.

For instance, I arrived at the conclusion that some physical differences existed between the arterial and venous states of the blood, which, if their full significance could be detected, would prove the nature of the vital force.

Having regard to the presence of iron in the blood of almost all animals, and to the important office it appears to fulfil, I was led to investigate the magnetic differences of the arterial and venous blood. I then proved experimentally* that the arterial blood is paramagnetic to the same blood in the venous state. But I had no sooner completed these investigations than I found they would be of little service unless the character of the magnetic force could be more clearly defined than it then was; I therefore continued my researches by making a careful investigation into the nature of magnetism.

My first experiments were conducted upon bar magnets, and I then established the fact that the equator and axis of a bar-magnet are always oblique.† This led to the inference that the same cause for obliquity existed in the bars as in terrestrial magnetism.

By a second series of experiments on bar magnets, on which a paper was read at the Physical Society of London, and subsequently published in *The Electrician*, the seat of polarity near the end of a bar magnet was found to change when two poles of the same sign were placed together, and to move to the line of contact.

My more recent investigations have been into the nature and cause of terrestrial magnetism, and I believe I have now determined the relations which subsist between magnetic force and gravitation, and further, I am able to prove that the motion of the celestial bodies, as well as the movements which germinal matter undergoes in the process of being converted into animal or vegetable cells, are equally under the influence of this force; and that the character of their motions, of their axial inclination, and of their orbits is determined by the description of resistance which the material unit, whether large or small, offers to the all-pervading current force.—Yours, &c.,

Reading, June 9th, 1887. Richard C. Shettle.

* Vide *Proceedings* of Royal Society, 157, 1875. † *Ibid*, 1879.

NATURALISTS AND THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Having just noticed in your influential journal of this week a paragraph of the visit of the Liverpool Biological Marine Association to the Menai Straits, I notice that you have credited Messrs. Siemens with the electrical work on board the L. S. A. ss. "Hyenæ," which was lent to them to convey the members to their destination—viz., Puffin Island. The reason for my writing you thus is to mention the fact of our fitting out the boat last autumn for the association, and perhaps it might interest you to have a few particulars of the installation. The dynamo is a "Phœnix" compound-wound E.M.F. 60-volt, C. 70 amperes, and is driven direct from the grooved fly-wheel of a Gwynne engine with a six ply cotton rope, there being four separate circuits from the machine, one for thirty 20 candle-power incandescent lamps (Edison-Swan), and one circuit each to two 3,000 candle-power Pilsen arc lamps, which are fitted with special lanterns and provided with suitable gearing for raising and lowering them from the fore and main masts. The other circuit consists of four 100 candle-power incandescent Edison-Swan lamps, in specially designed submarine lanterns, with insulated twin cable of 240 strands to obtain great flexibility, which pays out while the diver is descending with the light from a revolving drum. The switch-board has been especially designed by us to meet the requirements of a vessel engaged in salvage operations. I may add that the whole of this work has given great satisfaction to the owners, as the steamer has been busily engaged on several large ships which have been wrecked in the vicinity of the Mersey, and the electric light having proved of immense advantage in enabling the work of salving the cargo to be carried on at night as well as by day. I omitted to mention above that by means of suitable resistances on the switch-board it is possible to run either the whole of the incandescent and arc lamps at once, or by switching off the arc lamps to run only the incandescent, or *vice versâ*.

I merely mention this as there has been hitherto some difference of opinion as to the practical and successful working of arc and incandescent lamps from one machine, there being no perceptible difference in any of the lamps that are lighted, should one or more of the circuits be switched off, the speed of the machine, of course, remaining constant at 1,000 revolutions. I should like to bring before your notice that having been personally engaged in some fishing experiments by the electric light in the Menai Straits this winter, whenever we had occasion to lower the submarine lamp to the bottom of the river the raising of the lamp was invariably accompanied by shoals of fish.

Trusting that I have not encroached upon your valuable space, and feeling sure you will be kind enough to correct the statement which has appeared in this week's number in your next issue, if convenient.—Yours, &c.,

F. Hanson Perry.

F. H. Perry and Co., Limited, 36, Victoria-street, Liverpool, June 7th, 1887.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis:—

ON THE MIGRATION OF IONS AND AN EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITY.

BY DR. OLIVER LODGE.

(Concluded from page 62.)

Experiments on travel of both Ba *and* Cl *through jelly tubes.*

Four fresh tubes, numbered XII.–XV., each 40 centims. long, and more simply bent, were filled with the following jelly, containing sulphate of silver as a test for the presence both of Ba and of Cl. The jelly was made

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TABLE A.—Table of Results.

Date.		Tube XII.			Tube XIII.			Tube XIV.			Tube XV.		
		Distance travelled by			Distance travelled by			Distance travelled by			Distance travelled by		
Day.	Hour.	Ba.	Cl.	Current milliamp.	Ba.	Cl.	Current milliamp.	Ba.	Cl.	Current milliamp.	Ba.	Cl.	Current milliamp.
Feb. 22	xviii 30	started		·52	0	0	·36	0	0	·68	0	0	·50
,, 23	x 10	4·1	8·3	·41	3·9	7·8	·29	4·4	8·8	·54	3 93	8 0	·41
,, 23	xxii 10	6·85	13·9	·41	6·63	13·3	·29	6·5	14·5	·56	7·0	13·82	·41
,, 24	x 10	9·4	18·8	·41	9·0	18·0	·28	9·0	19·6	·53	9·6	18·9	·41
,, 24	xxi 45	12·1	24·1	·44	11·5	23·1	·32	11·6	25·0	·57	12 2	24·42	·44
,, 24	xxi 50	current	stopped	0	...	...	0	...	...	0	...	...	0
Three faint extra precipitations were now soon observed, besides those caused by the recent current. They are here referred to as *a*, *b*, *c*.													
Feb. 27	xii	(*a*) 4·75	...	0	(*a*) 4·8	...	0	(*a*) 4·9	...	...	...	...	...
,, 27	,,	(*b*) 12·85	(*c*) 26·5	0	(*b*) 12·26	(*c*) 25·68	0	(*b*) 12·4	...	...	...	...	...

TABLE B.

Volts applied	Date		Tube XII.			Tube XIII.			Tube XIV.			Tube XV.		
			Distance travelled by			Distance travelled by			Distance travelled by			Distance travelled by		
	Day	Hour	Ba	I	Current milliamp	Ba	I	Current milliamp	Ba	I	Current milliamp	Ba	I	Current milliamp
—	Mar. 5	xvi 22	0	0	·48	0	0	·36	0	0	·65	0	0	·48
—	,, 6	xxi 43	1·74	4·12	·40	1·78	3·00	·38	1·71	2·9	·56	1·6	2·82	·41
—	,, 6	x 10	4·6	8·08 (8 5)	·38	4·28	8·12 (8·72)	·29	4·3	8·4 (8·95)	·52	4 4	8·22 (8·8)	·34
—	,, 6	xiii 39	5·4	9·6 (10·3)	·49	5·12	(9·75) (10·4)	·37	5·03	9·93 (10·6)	·63	5·02	9 73 (10 5)	·48
—	,, 6	xx 56	7·15	13·16 (14·02)	·42	7·1	(13·31) (14·2)	·33	6 9	13·75 (14·65)	·57	6·95	13·5 (14·4)	·42
—	,, 7	xii 15	10 62	19·29 (20·5)	·44	10·7	19·61 (21·08)	·34	10·48	20·22 (23·6)	·63	10·4	19·7 (21·08)	·45
—	,, 8	x 20	—	—	·59	—	—	·46	—	—	·91	—	—	·63

Current stopped and another experiment arranged.

Tube XIII. broken accidentally.

28·6	Mar. 8	xv. 45	0	0	·40	—	—	—	0	0	·56	—	—	·39
29·14	,, 8	xxi. 51	1·58	2 7	·33	—	—	—	1·63	2 81	·45	1·5	3·0	·31
29·14	,, 9	ix. 45	4·1	8·0 (8·59)	·30	—	—	—	4·15	7·7 (8·3)	·43	4·2	8·5 (9·18)	·30
29·14	,, 9	xviii. 55	6·9	12·8 (13·8)	·38	—	—	—	6·7	12·6 (13·5)	·52	6·8	13·5 (14·6)	·38
29·0	,, 10	x. 15	10·8	19·73 (21·2)	·37	—	—	—	10 6	19·5 (21·1)	·53	10 6	20·61 (22·5)	·39
29·2	,, 10	xvii. 56	13·5	23 84 (24·6)	·40	—	—	—	13·59	23·54 (24·72)	·60	13·42	24·7 (25·83)	·41

by taking 40 cc. of the previous acetic acid gelatine and adding to it 10 cc. of the following solution—viz., 20 cc. of nitrate of silver sol. ($AgNO_3$ in 50 cc.) + 2 cc. sulphuric acid (H_2SO_4 in 10 cc.) + 78 cc. of water. Tube XIV. was ·562 centim. in diameter; the others were not measured. The tubes were arranged thus:—

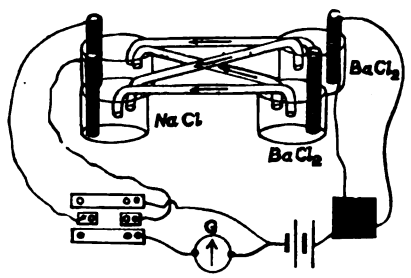

Fig. 8.

so that the current through any one of them could be measured. The anode vessels contained $BaCl_2$, the cathode vessels NaCl.

The E.M.F. of the applied battery was measured by an Ayrton and Perry voltmeter as 29 volts. (*See* Table A.)

Late on February 24 the current was stopped because the advancing ions had nearly met, and it was desired to observe whatever phenomenon might accompany their meeting. The tubes were left in position for a day or two, and by February 27 it was found that, while the precipitation boundaries due to the current still remained, three other fainter outlines had made their appearance, one, a fresh one, crawling along from the $BaCl_2$ end, the other two advancing beyond the current—formed precipitate. The three are labelled in the table *a*, *b*, *c* respectively, and their positions are indicated; but no meaning is attached to them.

The result of these experiments is to give a rough absolute determination of the rates of travel of Ba and of Cl through the jelly, and to show that the speed of Cl is pretty exactly twice that of Ba. Now, can this be assumed to be probably due to the fact that barium is a dyad, while chlorine is a monad? or is it due to the fact that the atomic weight of Ba, 137, is almost twice that of Cl_2—viz, 71? The simplest mode of examining this question is to replace the chlorine by bromine or iodine, whose atomic weight is quite different.

Similar experiments with iodine instead of chlorine.

The cathode vessels were filled with a solution of potassic iodide instead of the sodic chloride solution. An E.M.F. of 29 volts was again applied to the same four tubes, filled with the same jelly as before, and the results are subjoined. The precipitation on the advancing iodine side was, however, double; one faint outline in advance, which it was suspected might be due to a trace of chlorine impurity in the KI, and the main precipitation, which was considered to be real AgI. Successive positions of the faint advance cloudiness are recorded in the following table in parentheses. (*See* Table B.)

The cathode vessel was filled with a solution of potassic bromide containing 30 grammes of salt to 300 grammes of water. Tubes filled with same Ag_2SO_4 gelatine as before, each 40 centimetres long. (*See* Table C.)

As in the iodine experiments there was an advance cloudiness, faint but well defined, in advance of the main precipitate. The readings of the position of this are specified in the above table in parenthesis. The

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TABLE C.—Table of Results.

Date.		E.M.F.	Tube XII.			Tube XIII.			Tube XIV.		
			Distance travelled by		Current milliamp.	Distance travelled by		Current milliamp.	Distance travelled by		Current milliamp.
Day.	Hour.	Volts.	Ba.	Br.		Ba.	Br.		Ba.	Br.	
March 30	xv 50	26·8	0	0	·39	0	0	·57	0	0	·39
,, 31	ix 50	27·0	4·6	9·2 (9·7)	·35	4·4	9·6 (10·05)	·52	4·6	9·0 (9·4)	·34
,, 31	xvi 55	28·6	7·15	13·6 (14·37)	·44	6·6	14·21 (15·0)	·63	7·1	(13·4) (14·1)	·42
April 1	x 17	27·0	12·1	23·0 (23·9)	·39	11·8	23·8 (24·72)	·56	11·9	(22·6) (23·6)	·38

TABLE D.—Comparative Experiment on Ba, Sr, Cl, I, Br.

Date.		E.M.F.	Tube XVI.			Tube XVII.			Tube XVIII.			Tube XIX.			Tube XX.			Tube XXI.		
			Distance travelled by		Current milliamp	Distance travelled by		Current milliamp	Distance travelled by		Current milliamp	Distance travelled by		Current milliamp	Distance travelled by		Current milliamp	Distance travelled by		Current milliamp
Day	Hour	Volt	Ba	Cl		Ba	Br		Ba	I		Sr	Cl		Sr	Br		Sr	I	
June 11	xii 40	38·2	0	0	·76	0	0	·72	0	0	·65	0	0	·61	0	0	·56	0	0	·72
,, 11	xix 38	38·2	3·0	6·7	·75	3·3	6·1 (6·4)	·71	2·7	5·6	·64	2·6	6·6	·60	3·3	6·4 (6·6)	·57	2·9 —	6·0 (6·9)	·71
,, 12	x 15	37·8	9·1	20·3	·81	9·3	18·6 (19·4)	·76	8·9	17·5 (20·7)	·66	11·1	20·1	·64	11·3	18·6 (19·3)	·62	(10·9) —	18·2 (20·0)	·74
,, 12	xviii 35	36	13·6	23·9	·96	13·6	24	·86	12·8	25·2	·76	*	—	·74	*	—	·72	*	—	·86

* The Sr was not very clearly marked, so three tubes were refilled with stronger Ag_2SO_4 sol., viz., 15 cc. of of the Ag_2SO_4 sol. (instead of only 10), to 40 cc. of the gelatine sol. and another experiment started.

[The numbers in parentheses again refer to the position of the faint advance precipitates.]

June 16	xv 13	40·5	—	—	—	—	—	—	—	—	—	0	0	·57	0	0	·53	0	0	·51
,, 16	xxi 50	40·3	—	—	—	—	—	—	—	—	—	3·3	5·6	·56	3·1	5·7	·54	3·2	5·5	·52
,, 17	x 15	40·3	—	—	—	—	—	—	—	—	—	10·3	16·06	·39	10·0	16·0 (16·5)	·57	9·73	15·2 (15·8)	·53
,, 17	xvii 47	38·5	—	—	—	—	—	—	—	—	—	15·0	22·93	·90	14·5	22·6 (23·3)	·86	14·2	21·4 (22·35)	·82

meaning of it was not certainly made out, but it was provisionally set down as due to impurity.

Combined experiments on several substances.

It thus appears that Cl, Br, and I all go at about the same rate and about twice as quick as Ba. It remained to see what strontium and calcium did. Calcium is not an easy substance to experiment on; its sulphate is too soluble. But strontium is sufficiently easy, though not so sharp and well defined as the barium. To make a better comparison six tubes were taken, each 40 centimetres long, filled with the same Ag_2So_4 gelatine solution as before, and arranged in multiple arc with the same E.M.F. (about 40 volts) applied to all of them. This is the E.M.F. between the electrodes, and since gas is given off at the carbon electrodes something like three volts must be deducted for polarisation and for resistance of liquid in vessel. But it was not thought probable that absolute results could be of much use when the composition of jelly is so vaguely known. The diameter of tube XIX. was ·370 centim.

The six tubes were arranged as in Fig. 9; the two anode vessels being filled, one with $BaCl_2$, the other with $SrCl_2$, and the three anode vessels with NaCl, KBr, and KI, respectively; in each case 10 grammes of salt and 100 cc. of water. (*See* Table D.)

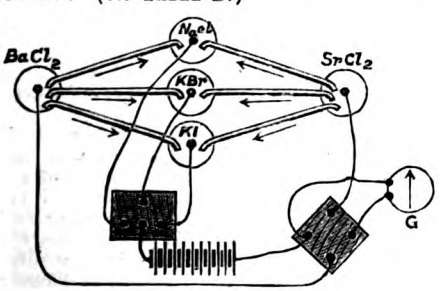

Fig. 9.

Determination of the resistance of the jelly-filled tube.

July 1.—One of the 40-centimetre tubes filled with plain gelatine gave 67,720 ohms resistance. The same tube had the jelly melted out, the tube cleared and filled with dilute acetic acid (centigramme molecule in 5 cc.), and its resistance was now 160,000.

Another determination, by Mance's method, gave for the acetic acid filled tube 142,000 ohms, at 21°C; for the jelly-filled tube at 19·5, 78,000 ohms; and for the same tube filled with dilute sulphuric acid (H_2SO_4 in 10 cc.) 730 ohms.

This jelly tube was then left to stand all night with its feet in dilute acetic acid. By the morning its resistance had increased, as the acid soaked up into it, to 84,000 ohms.

Improved experiments on the velocity of ions in free liquid.

Any siphon tube arrangement joining two open vessels cannot be free from difficulties caused by electric endosmose, whatever precautions be adopted. Hence a series of experiments were planned with one of the vessels closed and completely full, so that no more or less could be driven into or out of it, either by the action of the current or by changes of level, except such calculable changes as result from alteration of volume of electrode or solution near it, or from changes of temperature. To this end the cathode vessel was made of the shape shown in Fig. 10, and the experimental tube fitted to it by a ground joint. It was necessary to avoid evolution of gas, so the cathode vessel was filled with saturated sulphate of copper solution, and it was immersed in a constant-temperature water-bath. The tube was 40·7 centimetres long, and it was filled with dilute HCl (1 centigramme molecule in 5 cc.). The anode vessel contained a solution of baric chloride (10 grammes salt to 100 of water) and a carbon electrode.

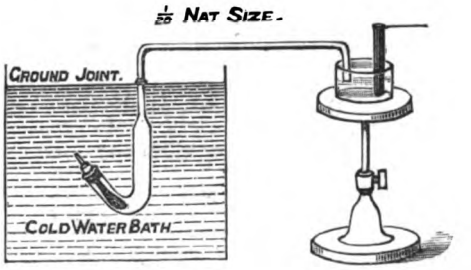

Fig. 10.

August 7.—The cathode vessel having been in the bath all night, and the temperature being 16·2°, the tube was put in at x. hrs 20 min., and the current started at x hrs. 48 min. with a difference of potential of 51·3 volts between the electrodes. A silver voltameter was included in the circuit.

By xxii. o'clock there was no ring formed in the tube, but in the bend near the cathode end of the tube there was a slight deposit. The temperature of the bath was still 16·2°. It was afterwards found that the silver plate of the voltameter had dissolved, and thereby broken contact.

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August 9.—Another precisely similar experiment; except that a galvanometer was used instead of a voltameter. Current started at xii. hrs. 15 min. with E.M.F. 50 6 volts. The galvanometer readings fell gradually from 6·7° to 3·8°. At xvi. hrs. 40 min. a disc of precipitate was found in the tube, the volts being now 49 7. The thickness of the disc was ·17, and the positions of its two faces were 3·79 and 3·96 centims. from the cathode end of the tube. Result sketched here.

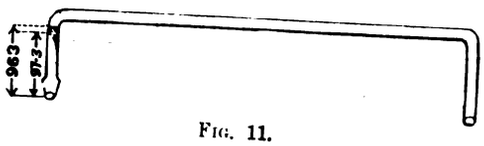

FIG. 11.

Summary of the experiment.

Time taken for ring to first form estimated at 4 hours.
Distance travelled by Ba 36 9 centims. $= b + x$.
" " SO_4 3·96 centims. $= a - x$.
Average difference of potential between electrodes, 50·15 volts.
Length of tube, 40·7 cm.
Current from 5 to 2·7 milliamperes.

The x in the above relates to a possible contraction of the contents of cathode vessel, to be determined later.

August 10.—Another similar experiment with same tube. Result sketched in Fig. 12.

Time taken for ring to form, 8 hours.
Distance travelled by Ba 37·3.
" " SO_4 3 55.
Difference of potential, 48·4.
Current from 4 to 1·5 milliamperes.

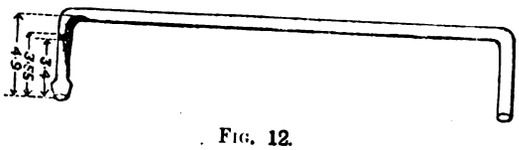

FIG. 12.

Blank experiment with no current on, to see the effect of diffusion.

August 12.—Tube connected at x. 30. No ring formed, but by August 17, xiv. 30, a slight precipitate was forming in the centre of the tube, *i.e*, after 5 days 4 hours.

(*To be continued.*)

NOVEL PHENOMENA OF ALTERNATING CURRENTS.

At the annual meeting of the American Institute of Electrical Engineers, held at New York, the following paper was read by Prof. ELIHU THOMSON:—

The actions produced and producible by the agency of alternating currents of considerable energy are assuming greater importance in the electric arts. I mean, of course, by the term alternating currents, currents of electricity reversed at frequent intervals, so that a positive flow is succeeded by a negative flow, and that again by a positive flow, such reversals occurring many times in a second, so that the curve of current or of electromotive force will, if plotted, be a wave line the amplitude of which is the arithmetical sum of the positive and negative maxima of current or electromotive force, as the case may be, while a horizontal middle line joins the zero points of current or electromotive force.

It is well known that such a current passing in a coil or conductor laid parallel with, or in inductive relation to a second coil or conductor, will induce in the second conductor, if on open circuit, alternating electromotive forces, and that if its terminals be closed or joined, alternating currents of the same rhythm, period, or pitch will circulate in the second conductor. This is the action occurring in any induction coil whose primary wire is traversed by alternating currents, and whose secondary wire is closed either upon itself directly or through a resistance. What I desire to draw attention to in the present paper are the mechanical actions of attraction and repulsion which will be exhibited between the two conductors, and the novel results which may be obtained by modifications in the relative dispositions of the two conductors.

In 1884, while preparing for the International Electrical Exhibition at Philadelphia, we had occasion to construct a large electro-magnet, the cores of which were about 6in. in diameter and about 20in. long. They were made of bundles of iron rod of about ⅝in. diameter. When complete the magnet was energised by the current of a dynamo giving continuous currents, and it exhibited the usual powerful magnetic effects. It was found also that a disc of sheet copper, of about ⅛in. thickness and 10in. in diameter, if dropped flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disc due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disc even when the attempt was made by holding one edge of the disc in the hand and bringing it down forcibly towards the magnet. In attempting to raise the disc quickly off the pole a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction to those in the coils of the magnet, and which currents, of course, would cause attraction as a result.

The experiment was, however, varied, as in Fig. 1. The disc D was held over the magnet pole, as shown, and the current in the magnet coils cut off by shunting them. There was felt an attraction of the disc or a dip towards the pole. The current was then put on by opening the shunting switch, and a repulsive action or lift of the disc was felt. The actions just described are what would be expected in such a case, for when attraction took place currents had been induced in the disc D in the same direction as those in the magnet coils beneath it, and when repulsion took place the induced current in the disc was of opposite character or direction to that in the coils.

Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given we will find that the disc D is attracted and repelled alternately; for whenever the currents induced in it are of the same direction with those in the inducing or magnet coil, attraction will ensue, and when they are opposite in direction repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disc D in accordance with well known laws, and in the latter case currents of the same direction will exist in the disc D and the magnet coil. The disc might of course be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of discs, rings, or coils superposed, and the results would be the same. Thus far, indeed, we have nothing of a particularly novel character, and doubtless other experimenters have made very similar experiments and noted similar results to those described.

The account just given of the effects produced by alternating currents, while true, is not the whole truth, and just here we may supplement it by the following statements:—

An alternating current circuit or coil repels and attracts a closed circuit or coil placed in direct or magnetic inductive relation therewith; but the repulsive effect is in excess of the attractive effect.

When the closed circuit or coil is so placed, and is of such low resistance metal that a comparatively large current can circulate as an induced current, so as to be subject to a large self-induction, the repulsive far exceeds the attractive effort.

For want of a better name I shall call this excess of repulsive effect the "electro-inductive repulsion" of the coils or circuits.

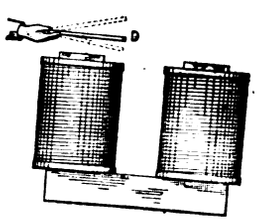

FIG. 1.

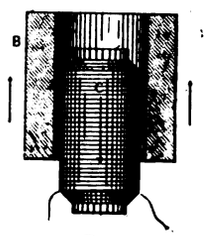

FIG. 2.

This preponderating repulsive effect may be utilised or may show its presence by producing movement or pressure in a given direction, by producing angular deflection as of a pivoted body, or by producing continuous rotation with a properly organised structure. Some of the simple devices realising the conditions I will now describe.

In Fig. 2 C is a coil traversed by alternating currents, B is a copper case or tube surrounding it, but not exactly over its centre. The copper tube B is fairly massive and is the seat of heavy induced currents. There is a preponderance of repulsive action tending to force the two conductors apart in an axial line. The part B may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire insulated, or not. If the coil C, or primary coil, is provided with an iron core such as a bundle of fine iron wires, the effects are greatly increased in intensity and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

The forms and relations of the two parts C and B may be greatly modified with the general result of a preponderence of repulsive action when the alternating currents circulate.

Fig. 3 shows the part B of an internally tapered or coned form, and C of an externally coned form, wound on an iron wire bundle, I. The action in Fig. 2 may be said to be analagous to that of a plain solenoid with its core, except that repulsion, and not attraction, is produced, while that of Fig. 3 is more like the action of tapered or conically wound solenoids and taper cores. Of course it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action and the amount of repulsive effort existing at different parts of the range.

In Fig. 4 the arrangement is modified so that the coil C is outside, and the closed band or circuit B inside and around the core I. Electro-inductive repulsion is produced as before.

It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effort, when the electrical middles of the coils or circuits are co-incident. In cylindrical coils in which the current is uniformly distributed through all the parts of the conductor section, what I here term the electrical middle, or the centre of gravity of the ampere turns of the coils, will be the plane at right angles to its axis at its middle, that of B and C in Fig. 4 being indicated by a dotted line. To

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repeat, then, when the centres or centre planes of the conductors, Fig. 4, coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion and distribution of current at any time in the two circuits or conductors.

It is not my purpose now to discuss the ways of determining the distribution of currents and mechanical effects, as that would extend the present paper much beyond its intended limit. The forms and relative arrangement of the two conductors may be greatly varied. In Fig. 5 the parts are of equal diameter, one, B, being a closed ring, and the other, C, being an annular coil placed parallel thereto, and an iron core or wire bundle placed in the common axis of the two coils increases the repulsive action. B may be simply a disc or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

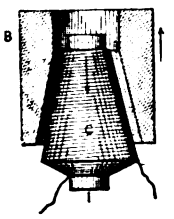

Fig. 3.

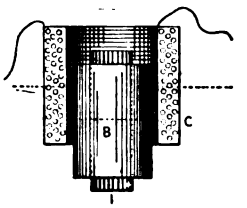

Fig. 4.

An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in Fig. 6. The alternating current coils C C′ are wound upon an iron wire bundle bent into U-form, and opposite its poles is placed a pair of thick copper discs, B B′, which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, &c.

If the iron core takes the form of that shown by I I, Fig. 7, such as a cut ring with the coil C wound thereon, the insertion of a heavy copper plate B into the slot or divided portion of the ring will be opposed by a repulsive effort when alternating currents pass in C. This was the first form of device in which I noticed the phenomenon of repulsive preponderance in question. The tendency is to thrust the plate B out of the slot in the ring, excepting only when its centre is coincident with the magnetic axis joining the poles of the ring between which B is placed.

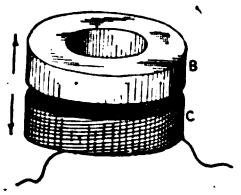

Fig. 5.

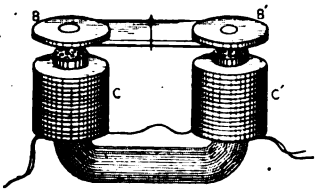

Fig. 6.

If the axes of the conductors, Fig. 5, are not coincident but displaced, as in Fig. 8, then, besides a simple repulsion apart, there is a lateral component or tendency as indicated by the arrows. Akin to this is the experiment illustrated in Fig. 9. Here the closed conductor B is placed with its plane at right angles to that of C, wound on a wire bundle. The part B tends to move towards the centre of the coil C, so that its axis will be in the middle plane of C, transverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i.e.*, deflective actions.

When one of the conductors, as B, Fig. 10, composed of a disc, or, better, of a pile of thin copper discs, or of a closed coil of wire, is mounted on an axis X transverse to the axis of coil C, through which coil the alternating

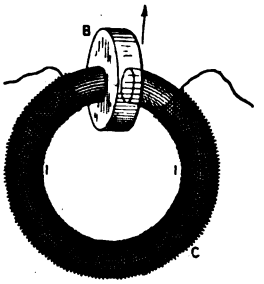

Fig. 7.

current passes, a deflection of B to the position indicated by dotted lines will take place, unless the plane of B is at the start exactly coincident with that of C. If slightly inclined at the start, deflection will be caused as stated. It matters not whether the coil C encloses the part B or be enclosed by it, or whether the coil C be pivoted and B fixed, or both be pivoted. In Fig. 11 the coil C surrounds an iron wire core and B is pivoted above it, as shown. It is deflected, as before, to the position indicated in dotted lines.

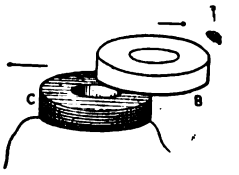

Fig. 8.

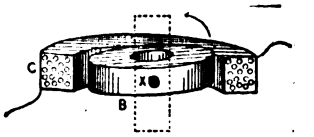

Fig. 10

It is important to remark here that, in cases where deflection is to be obtained, as in Figs. 10 and 11, B had best be made of a pile of thin washers or a closed coil of insulated wire instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring B in other directions than parallel to its circumference.

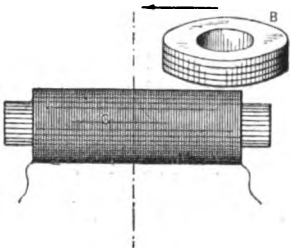

Fig. 9.

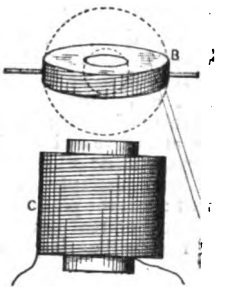

Fig. 11.

We will now turn our attention to the explanation of the actions exhibited, and afterwards refer to their possible applications. It may be stated as certainly true that were the induced currents in the closed conductor unaffected by any self-induction, the only phenomena exhibited would be alternate equal attractions and repulsions, because currents

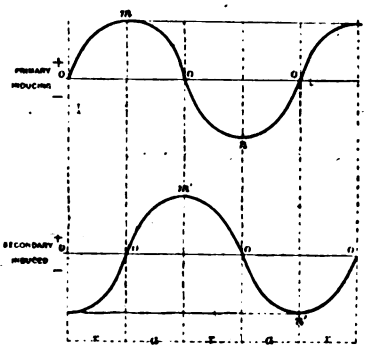

Fig. 12.

would be induced in opposite directions to that of the primary current when the latter current was changing from zero to maximum positive or negative current, so producing repulsion; and would be induced in the same direction when changing from maximum positive or negative value to zero, so producing attraction.

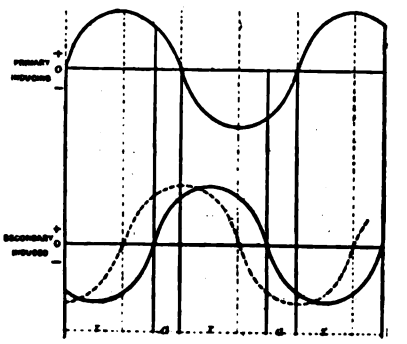

Fig. 13.

This condition can be illustrated by a diagram, Fig. 12. Here the lines of zero current are the horizontal straight lines. The wavy lines represent the variations of current strength in each conductor, the current in one direction being indicated by that portion of the curve above the zero line, and in the other direction by that portion below it. The

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vertical dotted lines simply mark off corresponding portions of phase or succession of times.

Here it will be seen that in the positive primary current descending from m, its maximum, to the zero line, the secondary current has risen from its zero to m^1, its maximum. Attraction will therefore ensue, for the currents are in the same direction in the two conductors. When the primary current increases from zero to its negative maximum n, the positive current in the secondary closed circuit will be decreasing from m^1, its positive maximum, to zero; but, as the currents are in opposite directions, repulsion will occur. These actions of attraction and repulsion will be reproduced continually, there being a repulsion, then an attraction, then a repulsion, and again an attraction, during one complete wave of the primary current. The letters r, a, at the foot of the diagram, Fig. 12, indicate this succession.

In reality, however, the effects of self-induction in causing a lag, shift, or retardation of phase in the secondary current, will considerably modify the results, and especially so when the secondary conductor is constructed so as to give to such self-induction a large value. In other words, the maxima of the primary or inducing current will no longer be found coincident with the zero points of the secondary currents. The effect will be the same as if the line representing the wave of the secondary current in Fig. 12 had been shifted forward to a greater or less extent. This is indicated in diagram, Fig. 13. It gives, doubtless, an exaggerated view of the action, though from the effects of repulsion which I have produced I should say it is by no means an unrealisable condition.

It will be noticed that the period during which the currents are opposite, and during which repulsion can take place, is lengthened at the expense of the period during which the currents are in the same direction for attractive action. These differing periods are marked r, a, &c., or the period during which repulsion exists is from the zero of the primary or inducing current to the succeeding zero of the secondary or induced current; and the period during which attraction exists is from the zero of the induced current to the zero of inducing current.

But far more important still in giving prominence to the repulsive effect

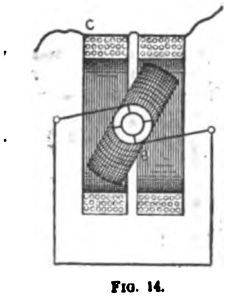

FIG. 14.

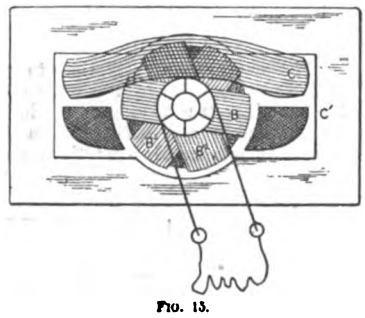

FIG. 15.

than this difference of effective period, is the fact that during the period of repulsion both the inducing and induced currents have their greatest values, while during the period of attraction the currents are of small amounts comparatively. This condition may be otherwise expressed by saying that the period during which repulsion occurs includes all the maxima of current, while the period of attraction includes no maxima. There is then a repulsion due to the summative effects of strong opposite currents for a lengthened period, against an attraction due to the summative effects of weak currents of the same direction during a shortened period, the resultant effect being a greatly preponderating repulsion.

It is now not difficult to understand all the actions before described as obtained with the varied relations of coils, magnetic fields, and closed circuits. It will be easily understood, also, that an alternating magnetic field is in all respects the same as an alternating current coil in producing repulsion on the closed conductor, because the repulsions between the two conductors are the result of magnetic repulsions arising from opposing fields produced by the coils when the currents are of opposite directions in them.

Thus far I have applied the repulsive action described in the construction of alternating current indicators, alternating current arc lamps, regulating devices for alternating currents, and to rotary motors for such currents. For current indicators a pivoted or suspended copper band or ring composed of thin washers piled together and insulated from one another and made to carry a pointer or index, has been placed in the axis of a coil conveying alternating currents whose amount or potential is to be indicated. Gravity or a spring is used to bring the index to the zero of a divided scale, at which time the plane of the copper ring or band makes an angle of, say, 15 degrees to 20 degrees with the plane of the coil. This angle is increased by deflection more or less great, according to the current traversing the coil. The instrument can be calibrated for set conditions of use. Time would not permit of a full description of these arrangements as made up to the present.

In arc lamps the magnet for forming the arc can be composed of a closed conductor, a coil for the passage of current, and an iron wire core. The repulsive action upon the closed conductor lifts and regulates the carbons in much the same manner that electro-magnets do when continuous currents are used. The electro-inductive repulsive action has also been applied to regulating devices for alternating currents, with the details of which I cannot now deal.

For the construction of an alternating current motor which can be started from a state of rest the principle has also been applied, and it may here be remarked that a number of designs of such motors is practicable.

One of the simplest is as follows:—The coils C (Fig. 14) are traversed by an alternating current, and are placed over a coil, B, mounted upon a horizontal axis, transverse to the axis of the coil C. The terminals of the coil B, which is wound with insulated wire, are carried to a commutator, the brushes being connected by a wire, as indicated. The commutator is so constructed as to keep the coil B on short circuit from the position of coincidence with the plane of C, to the position where the plane of B is at right angles to that of C; and to keep the coil B open circuited from the right angled position or thereabouts to the position of parallel or coincident planes. The deflective repulsion exhibited by B will, when its circuit is completed by the commutator and brushes, as described, act to place its plane at right angles to that of C, but being then open-circuited its momentum carries it to the position just past parallelism, at which moment it is again short-circuited, and so on. It is capable of very rapid rotation, but its energy is small. I have, however, extended the principle to the construction of more complete apparatus. One form has its revolving portion or armature composed of a number of sheet iron discs wound as usual with three coils crossing near the shaft. The commuator is arranged to short-circuit each of these coils in succession, and twice in a revolution, and for a period of 90 degrees of rotation each. The field coils surround the armature and there is a laminated iron field structure completing the magnetic circuit. I may say here that surrounding the armature of a dynamo by the field coils, though very recently put forth as a new departure, was described in various Thomson-Houston patents, and to a certain extent all Thomson-Houston machines embody this feature.

Figs. 15 and 16 will give an idea of the construction of the motor referred to. C C^1 are the field coils or inducing coils which alone are put

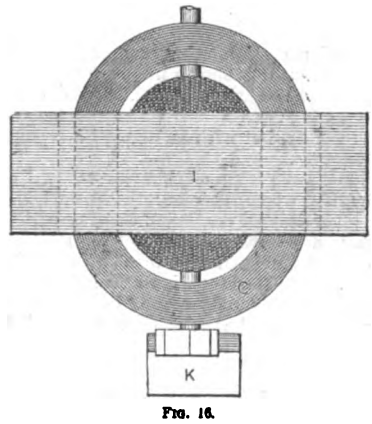

FIG. 16.

into the alternating current circuit. I I is a mass of laminated iron, in the interior of which the armature revolves, with its three coils B, B^2, B^3 wound on a core of sheet iron discs. The commutator short-circuits the armature coils in succession in the proper positions to utilise the repulsive effect set up by the currents which are induced in them by the alternations in the field coils. The motor has no dead point and will start from a state of rest and give out considerable power, but with what economy is not yet known.

A curious property of the machine is that at a certain speed, depending on the rapidity of the alternations in the coil C, a continuous current passes from one commutator brush to the other, and it will energise electro-magnets and perform other actions of direct currents. Here we have, then, a means of inducing direct currents from alternating currents. To control the speed and keep it at that required for the purpose, we have only to properly gear the motor to another of the ordinary type for alternating currents namely, an alternating current dynamo used as a motor. The charging of storage batteries would not be difficult with such a machine, even from an alternating current line, though the losses might be considerable.

In the discussion which followed—

Mr. MAILLOUX said: I might add, in corroboration of the statement made by Prof. Thomson, that I am perfectly aware myself that the ironclad dynamo, as we have heard it called very recently, is another of those things that have been done before. I remember distinctly reading one of Prof. Thomson's patents where the direct magnetising effect of the coil on the armature itself is adverted to, and I do not think there can be any dispute as to the fact that it had been brought out before; and I would also state that I myself made experiments with dynamos in which the same thing was made out as early as 1879, and I have small models now which may be of interest at some later time. There is one very interesting feature of it that is mentioned by Prof. Thomson. It think it is the phenomenon which he illustrated by means of his first figure, noting the repulsion and the attraction that takes places when the current is reversed in an ordinary electro-magnet. I could not help thinking at the time of some experiments made some years ago by Elphinstone and Vincent, and about which I once took it into my head to write something. The effect was brought out by Elphinstone and Vincent of the magnetic circuit that we now so well know and use in dynamo-electric machines. I was very much struck by the statement of Faraday in his "Experimental Researches," where he speaks of lines of force expanding during the action of the beginning of the passage of current through a circuit and of their collapse when the current is discontinued or decreased; and I remember

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making a note in this article (which you will find somewhere in the London *Electrician*, several years back) of experiments or observations made by me to show that that phenomenon was observable in an ordinary electromagnet. I have been able, by means of a delicately-suspended needle, or by a very thin piece of iron wire fastened to the pole—so that it might place itself in the lines of force and follow the oscillations of the lines of force—to trace a positive motion in the lines of force which would exactly correspond to that just referred to by Prof. Thomson.

In answer to Mr. Prescott, Prof. THOMSON said:—In regard to the measuring instruments, I have used the principle in several ways. The matter has not been carried sufficiently far as yet to determine all the points on the subject, but I have used gravity and a spring in both cases. However, I find there does not seem to be any regular law, perhaps any more than there is with an electro-magnet, for the decrease of the effect by distance, except when the distances become very large. The very fact of a change of position changes the relations of the currents themselves and of the relations between the two currents, so that we can hardly regard the problem as any different from the problem of an electro magnet attracting its armature. When the armature is placed at a certain distance, there is a certain distribution of magnetism; when it is taken to another distance the distribution is so changed that we could not consider that the centre of gravity, so to speak, of the magnetism is the same in the two cases, and the re-distribution will depend on the length, the diameter of the core and the sizes of the armatures, so that the problem becomes a very complex one. But I have made a very curious application of the principle in this way: I have taken an ordinary fruit jar and put in it a disc of a certain thickness and attached to it a bulb of glass and floated it in alcohol or water until the gravitational effect was so overcome by the flotation that it was almost indifferent, but it would just settle down to the bottom of the jar. I then put an alternating current coil below it and passed a current of gradually increasing amount. Gradually the disc would begin to lift itself, and at a certain current would float to a certain height, standing in the liquid supported by the repulsion. There we have a very excellent illustration of the means of getting at probably the relational effect of repulsive effort under different conditions.

Mr. CARL HERING: I would like to ask Prof. Thomson how the magnetic attraction compares with its induction. If the closed copper disc were to be made of iron, there would be attraction. Now, how does that attraction compare with the repulsion in case it is not magnetic? I ask that in order that we may get some idea of the strength of this repelling force.

Prof. THOMSON: I have not made any determinations with that object in view—that is, to determine the relation as to, as I understand it, the attraction of the magnet coil for its core. I think we can say, however, that it compares very well, only that the copper band, of course, naturally occupies a greater space, and uses energy of current flowing in it. If we have a current flowing in a coil attracting an iron core, and the iron core is thoroughly divided so as to avoid currents in the iron itself, we would get electro-magnetic attraction pure and simple without necessary loss of energy; but in the case of the copper band there is undoubtedly, where large work is being doing, a loss of energy due to the flow of heavy currents in the conductor; but in the case of a disc which is deflected, the disc saves itself that loss by throwing itself more or less at right angles. It is only when you are resisting the motion by a counterweight that the loss amounts to a great deal. Allow the thing to move, and it relieves itself of the stress by leaving the point of greatest stress.

Mr. J. A. POWERS: I had a very interesting experience in the line of Prof. Thomson's address about the lag of heavy currents which I wish to bring to your notice. At Troy we are making an alternating current dynamo, producing direct currents from it. In other words, a simple multipolar dynamo, with this exception, that the armatures are in two layers, the neutral point on one armature corresponding with the maximum point on the other. Those two armatures are connected to a single commutator, there being two bars connected with one armature and the next two bars with the other; the positive of one and the positive of the other; the negative of one and the negative of the other; in that relation, a brush being put on of a certain width, we found some curious results. With plating machines of low tension we found we could increase the width of contact to such an extent that we seemed to collect the entire current from both sides of the armature; in other words, the current seemed to be prolonged from each side of the armature, so that we were practically collecting the current from both sides. The moment we got to high tension currents we failed. Without apparent lag of the current, or whatever that was, the minute we increased the tension of currents up to two or three or four hundred volts we failed entirely. But the point I wished to bring to your attention was that we could make that contact of considerable width and apparently get a larger power from the same amount of material in the machine in low tension work than we could when we got too high tension, and apparently there existed there this feature of lag of heavy currents which Prof. Thomson first brought up.

Prof. THOMSON: I do not think you can say that heavy currents lag any more than light currents. A heavy current is nothing more or less than the flowing around of so many light currents. In the closed circuit of a coil it is the same current going round many times, as compared, you may say, with parallel currents which represent the current that goes in the fine coil repeated side by side so many times; and the lag ought to be the same in both cases. I find, for example, that it does not matter in these experiments whether I use a copper ring or a closed coil of a finely-wound coil; I might use No. 36 wire, provided I could get as much copper into the same space with No. 36 wire that I could get with a heavy mass of copper. That, of course, I cannot do, but if I could I have not the slightest doubt that the high electromotive force closed on this would have the same lag as heavy currents closed on this. In one case it has greater length; in the other it has greater volume, which lags the current. Mr. Powers is probably working with high potentials in one case and quite low potentials in the other. Now a high potential machine is a ticklish thing to handle anyhow. You must put your brushes on and carry the coil away not a moment too late or you will have a flash and short-circuit of the commutator from one point to the other. I am speaking of the type of machine you refer to. The low potential current, however, permits you to have a considerable variation in the point of connection without provoking bad sparking and flashing; you no doubt need to put the extra overlap of brushes brought on the coils into action at the moment they are developing very low electromotive force, and take them out when they are developing nearly no electromotive force. That you could not do in a machine of that type with high potentials, because if you keep the coils in beyond their time of possessing electromotive force which could just sustain the circuit, you would have a flash; there would be an alternation at the slot in the commutator, which would cause a reverse current.

Mr. POWERS: The action I was speaking of was not flashing at the commutator, but the curious "growling" of the machine against itself; for instance, the relation between ten volts and one hundred volts on the same machine, if you choose to couple them up directly, and the same brushes would give you that slowing down and growling effect, while in the other case the brushes worked smoothly and gave good results.

THE EQUITABLE TELEPHONE COMPANY'S INSTRUMENTS.

The discovery some time since—for discovery it may be called—of the fact that good and practicable telephone receivers can be constructed upon

the lines of the so-called "English Mechanic" telephone (a type which, as is well known, is disclaimed from the Bell patents), is at length beginning to bear fruit, and we have now at least three public companies besides private individuals, who are making instruments of this class, and offering them to the public for sale outright. It will be recollected that this type of receiver consists of a membraneous diaphragm, carrying a small iron disc or amature at the centre.

The possession, however, of a receiver does not finally extricate from difficulty those who are—more or less justifiably—trying to "get round" the United Telephone Company. It is necessary also to make sure that the transmitter does not infringe the claim in the Edison patent—the solitary claim which now remains out of the original thirty. The instrument must contain no diaphragm, and the latter term must be construed according to the "legal" definition, which is well known to be of somewhat extended application. The solution of this difficulty which has been adopted by

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the Equitable Telephone Company seems, however, to the lay intellect to be perfectly unassailable, while at the same time the complete demonstration of the fact that a Hughes microphone will act by direct impact of sound waves is not without scientific importance. The microphone transmitter employed by this new company (and the particular form of which has been designed by Mr. Campbell Swinton) consists of a row of carbon pencils strung upon a platinum wire, whose lower ends rest lightly upon an insulated horizontal rod of carbon. The whole of these parts are supported by a heavy rectangular frame of lead, and this again is suspended from the back board by means of two short pieces of india rubber, so that no vibratory impulse can possibly be communicated from the board—which would otherwise constitute a legal diaphragm—without passing through the india rubber cords and the heavy lead frame.

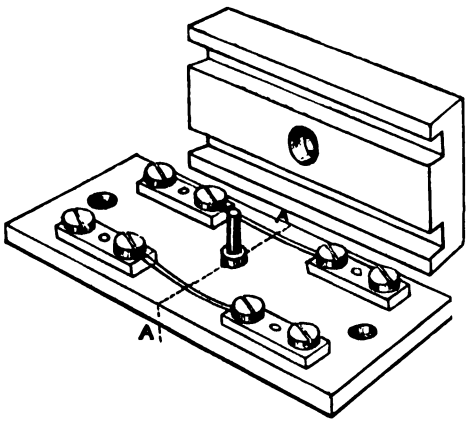
The fact that the action of the instrument does depend upon the direct impulse of the sound waves was recently demonstrated to our own satisfaction by Mr. Campbell Swinton, by taking the transmitter off the frame, and hanging it from the ceiling by means of a long piece of twine. Under this severe test we found the articulation to be just as loud as well as distinct as when the carbons were in their place upon the board.

The pressure of the carbon can be regulated with great nicety by slightly tilting the frame. The company prefers to use a direct battery current to line, dispensing altogether with induction coils, and we are informed that on long lines it has been found that the number of cells required for the transmitter in no case exceeds the number used for the call bells.

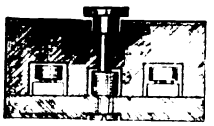
We are indebted to the company for the above engraving.

RASHLEIGH PHIPPS' SLATE-CASED CUT-OUT.

The adjoining figures illustrate the double pole fusible cut-outs made in slate or marble by Mr. Rashleigh Phipps, and to which we referred in a recent note. We may mention that cut-outs of a similar character are also supplied by the United Electric Light Company, and are made with enamelled surface having a very handsome appearance. There can be no two opinions as to the superiority of this make over the old-fashioned wood-cased type. If it were not for the fact that safety-fuses so extremely seldom come into action, there is no doubt that the wooden blocks would long ago have received emphatic condemnation.



Phipps' Slate-Cased Cut-Out.—Perspective View.



Section at A A.

THE TELEGRAPH SERVICE.

DISCUSSION IN THE HOUSE OF COMMONS.

In the House of Commons, on Monday last, on the vote of £1,500,248 for the Telegraph Service,

Dr. CAMERON urged the desirability of revising the bargain made in respect of telegraphs many years ago, and of inquiry as to the amount of waste thereby incurred, particularly with reference to the charges made by railway companies and others for the maintenance of telegraph wires.

Mr. MOLLOY inquired what progress had been made in putting telegraph wires underground, with a view to avoiding the inconvenience caused by breakdowns of overhead wires, especially when great storms occurred.

Mr. H. HEATON suggested that the twenty years' monopoly of the Submarine Cable Company, which expires next year, should not be renewed, but that the cables to the Continent should be owned by the Government.

Mr. RAIKES considered that it was practically not within the bounds of equity for the House of Commons to seek to review an arrangement legally made and entered into with the railway companies as to the maintenance of postal wires. The Government could not, without a breach of equity, attempt to interfere with the arrangement with railway companies for the maintenance of telegraph wires. He was not prepared with the actual figures of the extent of our present system of underground telegraphic communication. The Government was, however, developing that system, especially in London and in large towns. The network of wires seen in London were for the most part not telegraph wires under the control of the Government, but were the property and under the control of telephone companies. The country would hardly sanction a general extension of the underground system, the lowest estimate for which was put at £1,500,000. There were undoubtedly certain dangers from the overhead system, but there was the advantage of greater facility for repair. The question was being carefully considered, and the Department were of opinion that in the metropolis and in large towns underground wires might with advantage be substituted for overhead wires. He called attention to the wonderful celerity with which the damage to the overhead wires last winter was repaired, and expressed the acknowledgment of the Department to the Royal Engineers for so ably seconding the efforts of the Department. Negotiations had already begun as to the policy that should be adopted when the concession to the Submarine Cable Company came to a natural end. He hoped that the Committee would not press for any more positive statement of policy. There was a very full recognition of the paramount importance of the Government having control over the means of telegraphic communication with the Continent.

Dr. CAMERON complained that directors of railway companies made use of the privilege of franking telegrams for other purposes than the regulation of traffic. As the Postmaster-General did not seem to attach sufficient importance to the subject, he moved to reduce the vote by £25,000.

The Committee divided—

For the reduction	60
Against	132
Majority against	—72

Mr. S. LEFEVRE asked whether the £500,000 deficit on the introduction of sixpenny telegrams did not include £350,000 interest on the capital embarked in the purchase of the telegraph system, together with £150,000 or £200,000 for new plant. If this were so, was he not right in saying that an actual increase in revenue had followed the introduction of the sixpenny telegrams?

Sir W. HARCOURT said the net profit of the Postal and Telegraph Services was becoming less and less every year. He should be glad to learn what hope there was of the telegraph service paying its way.

Mr. RAIKES said the position was this, that they had a permanent charge against the revenue of £326,000 interest on capital, plus the actual deficit on the working of £223,000. So that, on the whole, the figures came out for last year as representing a deficit of something like £550,000. A very large portion of the expenditure last year was due to plant, using the word in its largest sense. The number of telegrams sent for some weeks past had exceeded a million per week, compared with 700,000 or 800,000 in the corresponding period of last year, when the sixpenny telegram was introduced. The figures showed that the sixpenny telegram was almost in its infancy, yet the progress which it had made was so rapid that it was almost impossible to forecast the dimensions of its growth. It was impossible to say whether the introduction of sixpenny telegrams had really paid its way or not. Last year they produced a considerable increase of revenue, but there had also been a considerable and a larger increase of expenditure. It was hoped that while in the course of the coming year the revenue would continue to increase, the expenditure would be largely diminished. That being so, he looked with some hope to the future of the sixpenny telegram. It must, however, be seen that the demand for fresh sites, accommodation, and plant must disturb any calculations which might be made.

Mr. S. LEFEVRE said the statement of the Postmaster-General was rather reassuring with regard to the future, showing that the actual number of telegrams had increased to a much greater extent than had been expected, but the average receipt was less, and the two apparently about balanced each other. He suggested that the payments of large amounts of expenditure should be spread over a period of years, so as not to disturb the averages.

The vote was then agreed to.

LEGAL INTELLIGENCE.

Gouraud v. The Consolidated Telephone Construction and Maintenance Company (Limited).

This was an action heard before Baron Pollock and a special jury in the Court of Queen's Bench on Tuesday, in which the plaintiff sued to recover certain fees which he alleged to be due to him as a director of the defendant company, in respect of the period from March 31st, 1883, to August 18th, 1884, when he resigned his seat at the Board. Mr. Fletcher Moulton, Q.C., with whom was Mr. Walter, appeared on behalf of the plaintiff, the defendant being represented by Mr. Finlay, Q.C., M.P., and Mr. Reginald Brown.

In opening the case for the plaintiff, Mr. Walter said in effect that Colonel Gouraud was one of the original directors of the company, appointed under its Articles of Association at the date of its incorporation in 1881, and for a certain time he acted in that capacity, but at a subsequent period of its history found it necessary to resign his position, and for a certain space of time after that the defendant company endeavoured to conduct its business without that gentleman's assistance. Towards the close of 1882, however, the majority

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of the Board came to the conclusion that the co-operation of Colonel Gouraud was essential to the success of the company's operations which it had then in hand, and they determined to invite him to rejoin the directorate. The result of that decision was that they passed a resolution, on the 18th January, 1883, asking him to become again a director, which he did. Unfortunately, about that time the affairs of the company were not in a very prosperous state, and, in consequence of that, on the 20th of April, the directors as a body came to the resolution to relinquish their fees for the financial year from the 31st of March previously. It was from a misconstruction of this resolution on the part of the defendants that the present action arose. After that resolution had been carried in the month of May a general meeting was held, at which the chairman announced to the shareholders that until such time as the company became prosperous the directors had agreed to forego their fees, but reserved their right to recoup themselves when the company attained more flourishing circumstances. In January, 1884, the chairman of the company, Sir Julius Vogel, was abroad, and during his absence it was necessary that someone should undertake the duties of his position. Accordingly, Colonel Gouraud was invited to assume that responsibility which he did on the 5th of February, but he pointed out that owing to the great labour that it involved, the resolution pledging the directors to forego their fees should be relaxed in his favour, and it was agreed that Colonel Gouraud should be paid at the rate of £1,000 a year, as deputy chairman, during Sir Julius Vogel's absence, in addition to his fees as a director, that portion of his fees up to the 31st March, 1883, only standing, in common with the fees of the rest of the directors, in abeyance. Sometime in May, 1884, a committee of investigation was appointed to inquire into the affairs of the company, and as the result of the report of that committee Colonel Gouraud issued a circular on the 23rd of July to the shareholders, setting forth the circumstances under which he joined the Board. Subsequently, at the general meeting in the same month an attack was made upon him and several other directors, in consequence of which, on the 18th of August, he retired from the Board, and lodged a claim with the secretary for the remuneration due to him from 31st March, 1883, up to the date of his resignation. He (Mr. Walter) would submit that Colonel Gouraud never relinquished his fees for that year, the defendants' case being that he had.

Colonel Gouraud was then called, and gave evidence to the effect that with the exception of pledging himself to the resolution relinquishing his fees down to the 31st March, 1883, he had never undertaken to forego any other claim he had on the company.

Cross-examined by Mr. FINLAY, witness deposed that the part of the circular he had addressed to the shareholders in July in reply to the allegation of the report of the committee of investigation, and which stated, "The report omits to mention that no part of the £1,000 remuneration so provided was drawn by me. I have voluntarily resigned my right to it," referred only to the few weeks he was a director, from the 5th of February (when he became deputy chairman) to the 31st March, 1883. Some correspondence between the secretary and Colonel Gouraud, as well as a circular issued simultaneously to the shareholders by Messrs. Spensley and Carnegie, then directors, who said "we think it right to say that Colonel Gouraud rejoined the Board of your company in January, 1883, at the earnest and repeated solicitations of the Board, and that of the remuneration of £1,000 a year referred to in the report nothing whatever has been paid to Colonel Gouraud, and for the year in question was voluntarily relinquished by that gentleman," were then submitted, witness alleging that the latter statement had also reference to the few weeks' tenure of his office prior to the 31st March, 1883.

The Hon. Mr. Spensely was next examined in support of the plaintiff's case, and in the course of cross-examination admitted that he could not positively say that the statement quoted from the circular, of which he was the joint author with Mr. Carnegie, referred to the whole year ending 31st March, 1884, or to the portion of the previous twelve months during which Colonel Gouraud was a director.

Mr. FINLAY, on behalf of the company, contended that the statements of the circulars referred to could bear no other interpretation than that they had reference to the whole of the financial year, from the 31st March, 1883, to the 31st March, 1884, in support of which contention he emphasised the fact that neither of the circulars saw the light until July, 1884, and could only refer to that period. He further contended that at the general meeting in July Mr. Fitzgerald, who was then chairman of the company, congratulated the shareholders, in the hearing of Colonel Gouraud, that the latter, in conjunction with the rest of the Board, had waived his right to his remuneration for the period in question. It was true that his learned friend maintained that Colonel Gouraud on that occasion muttered the words "mine refers to the previous period," as appeared by the shorthand notes of the proceedings, but if Colonel Gouraud made use of that expression, it was audible only to the reporter and to the chairman, and could not be regarded as a serious argument in the plaintiff's favour, more especially as on the conclusion of the chairman's speech Colonel Gouraud himself addressed the meeting for half an hour, and made no further allusion to the circumstance, and did not openly deny in the hearing of the shareholders—which he ought to have done—that he had agreed to forego his fees for the whole of the financial year ending 31st March, 1884.

Mr. Fitzgerald, Mr. Baker, Sir William Armstrong (directors), and Mr. Curtoys (secretary to the company) were then called, and gave evidence in support of Mr. Finlay's contention, Mr. Fitzgerald alone admitting that he heard Colonel Gouraud in a subdued voice use the words "mine refers to the previous period" at the general meeting in July.

Mr. Taunton, the shorthand writer who supplied the report of the proceedings, swore to the accuracy of his notes, which concluded the evidence on both sides.

Mr. FINLAY and Mr. MOULTON having each addressed the jury,

His LORDSHIP summed up, reviewing the whole of the documentary and other evidence, and

The Jury, after a short deliberation, found for the plaintiff, allowing him £1,091. 4s. 7d., the amount claimed, minus the sum paid into court by the defendants.

Von Chauvin v. Anderson and Others.

This was an action of libel heard before Mr. Baron Pollock and a special jury, on Wednesday last, in respect of a paragraph which was published in October, 1886, in *The Electrician*, a newspaper belonging to the defendants, and which, it was alleged, imputed fraud to the plaintiff. The defence to the action was a denial that the paragraph in question bore the meaning complained of, and the defendants further pleaded that they had published an apology, and they paid 40s. into court.

Mr. R. T. Reid, Q.C., and Mr. Arbuthnot appeared for the plaintiff; Mr. Finlay, Q.C., and Mr. Pollard were for the defendants.

The plaintiff was the principal official in the United Kingdom of the Western Union Telegraph Company, who, besides possessing a network of telegraph wires on the American Continent, are also the lessees of two Atlantic cables connecting Nova Scotia with England, and the libel in question, which was headed "Telegraph Frauds," was as follows:—"Serious accusations are brought against certain of the local officials of the Western Union Cable lines as to systematic tampering with or delaying Stock Exchange messages; whereby it is believed large sums have been fraudulently obtained." The plaintiff having complained of this paragraph as being utterly false, the defendants inserted an apology in their paper, the terms of which, however, were not considered satisfactory, and it was not until after the writ was issued that they published a second apology in which they acknowledged the statement to be entirely erroneous, and repeated an expression of regret which they had previously made that it should ever have caused annoyance to the plaintiff.

Mr. REID, in opening the case, having referred to the general facts, said the plaintiff would be content if this apology, which appeared so late and had not been published as the plaintiff required in *The Times* as well as *The Electrician*, should now be made in open court.

Mr. FINLAY said the apology was ample; and he did not see that he could add anything to it.

The plaintiff was then called, but his examination had scarcely commenced when a consultation having taken place between the learned counsel at the instance of the learned judge,

Mr. FINLAY said it was agreed that a juror should be withdrawn. He desired to state at the same time that it was never intended to convey any imputation whatever on the plaintiff or any other English official of the company, nor did he believe that the paragraph was read by the public as intended to refer to the plaintiff. Several of the defendants were themselves interested in the plaintiff company and were obviously, therefore, the last people to wish to discredit it, and he might add that the paragraph would never have appeared at all but for the accident of the editor being absent at the time.

Mr. Baron POLLOCK said the course that had been taken was a good illustration that unless a real charge was intended to be made the apology should be handsome and complete. Half-hearted apologies were very poor things, and sometimes tended to aggravate the original attack. He was sure a better end had been made of this case not only for the plaintiff, but for the defendants, than by any verdict which the jury might have given.

[The above is *The Times* report of this case, with one alteration, or rather correction, "Union" for "Atlantic," in the 16th line.—ED. *E.*]

CRICKET.

SS. "ELECTRA" v. MALTA ATHLETIC CLUB.

A match was played at Valetta Parade Ground, Malta, on May 28th last, between these elevens. We append the score:—

SS. "ELECTRA"	1st inn.		2nd inn.
H. Buckmaster, b Burdon	6	c Kirton, b Tortell	35
W. Ansell, c and b Bonavia	0	b Jones	20
J. Hogg, b Bonavia	9	b Bonavia	17
R. Greey, b Kirton	18	not out	0
A. E. Kennelly, b Burdon	1		
W. R. Holmes, st Trulock, b Jones	11	b Bonavia	5
W. Partridge, b Kirton	3	c and b Kirton	17
A. Beard, c Bonavia, b Kirton	0	c Trulock, b Kirton	6
E. Gardiner, b Kirton	0		
S. Baxter, run out	8		
S. Blandford, not out	0	run out	6
Byes 6, wides 2	8	Byes 11, wides 1	12
Total	59	Total	118

MALTA ATHLETIC CLUB.

J. Ghio, b Greey	0	J. Cooley, b Greey	4
Alf. Trulock c and b Greey	22	A. Tortell, c and b Greey	7
R. Kirton, b Greey	22	W. Burrell, not out	0
A. Bonavia, b Greey	1	T. Levy, st. Buckmaster, b Greey	0
Arthur Trulock, b Hogg	13	Byes 4, wides 2	6
W. Jones, c and b Greey	13		
C. Burdon, run out	12	Total	100

MARRIED V. SINGLE.

A match was played at Waterville, Co. Kerry, on Whit Monday, between the Married and Single members of the three cable companies (Anglo-American, Valentia; Direct U. S., Ballinskelligs; and Commercial, Waterville). The weather, though cloudy, was fine and favourable. There being some fairly good cricketers on both sides, this match had been anxiously awaited by all parties and was looked forward to with much interest.

The married team was captained by Mr. J. Graves (Valentia), and the single team by Mr. L. Carmichael (Waterville). Mr. Graves having won the toss, and several of his men having just completed a twelve mile drive, put in his opponents first. The ground was in good order.

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The single men, by careful play, put together 61 runs in their first innings, but owing to some inexplicable bad luck all the married wickets fell for only 15 runs.

In the second innings the single men added 31 to their score, and the married team had to face an apparent forlorn hope of pulling up a leeway of 77 runs Nothing daunted, and placed on their mettle with this state of affairs, the effort was commenced, but with the fall of the two first wickets not a single run had been scored in their favour. Messrs. Armstrong and Smith then succeeded in making a stand, which made the game assume a more hopeful appearance. Well supported in their efforts by those who followed them, a tie was at length reached amidst great excitement and the captain, by a fine hit for two, secured the palm for the married team with three wickets to spare.

EASTERN TELEGRAPH COMPANY v. ST. MILDRED'S.

To the Editor of the "Electrician."

SIR,—In your issue of the 3rd inst., under the heading "Cricket," The Eastern Telegraph Company v. The St. Mildred's C.C., I notice it is stated that the latter team was "mainly composed of *employés* of the Anglo-American Telegraph Company." Now there was only one man playing who is in any way connected with this company, and to the surprise of many, himself included, he made the top score for St. Mildred's. As your paper is forwarded to all the stations of our company, I feel sure you will correct the inaccuracy by inserting this in your next issue.—Yours, &c.,

R. J. EDWARDS, Captain A. A. T. C. C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 8.		BUSINESS DONE WEEK ENDING JUNE 8. Highest.		Lowest.	
Anglo-American	35½,	36½	.....	35½	.....	—
Do. Preferred	58,	59	.....	58½	.....	57½
Do. Deferred	14,	15	.....	14	.....	—
Brazilian Submarine	11½,	11⅝	.....	11 5-16	.....	11½
Cuba	12,	12½	.....	—	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2½,	3	.....	—	.....	—
Do. Preference	7,	8	.....	—	.....	—
Direct United States Cable	9,	9½	.....	9	.....	—
Eastern Telegraph	10⅝,	10⅞	.....	10⅞	.....	10⅝
Do. 6 per Cent. Preference	14,	14½	.....	14½	.....	14½
Do. 5 per Cent. Debentures, 1899	107,	110	.....	109	.....	—
Eastern Extension	11½,	11⅝	.....	11⅝	.....	11⅝
German Union	10½,	11	.....	—	.....	—
Globe Telegraph and Trust	5⅜,	5⅝	.....	5⅝	.....	5½
Do. Preference	12⅞,	13½	.....	13 1-16	.....	12⅞
Great Northern	13¾,	14	.....	14⅛	.....	—
Indo-European	84,	85	.....	—	.....	—
Reuter's	7⅞,	8½	.....	8½	.....	8
Submarine	180,	190	.....	—	.....	—
West India and Panama	⅝,	¾	.....	11-16	.....	⅝
* Do. 1st Preference	8½,	9	.....	8½	.....	—
Western Brazilian	7⅛,	8⅛	.....	8⅛	.....	7 15-16
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	104,	107	.....	106	.....	—

* x.d. 6s. on account of arrears.

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	.....	—	.....	—
Oriental	¼,	⅜	.....	5-16	.....	—
United Telephone	13,	13½	.....	13½	.....	13 3-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅞,	3⅛	.....	—	.....	—
Do. (fully paid)	4,	4½	.....	4	.....	—
Swan	1½,	1½	.....	1 7-16	.....	1½
Maxim Weston	3-16,	5-16	.....	¼	.....	—

MISCELLANEOUS.

Telegraph Construction	36,	37	.....	36⅞	.....	36½
India Rubber, Gutta Percha, and Telegraph Works	23,	24	.....	23⅞	.....	23½

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The directors of this company have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income-tax, for the quarter ended 31st March last, and payable on the 24th inst. The books of the company will be closed from the 16th to the 23rd inst, both days inclusive.—The traffic receipts of the company for the week ended 3rd inst. amounted to £4,473.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of May was 4,040, estimated to produce £3,050, against 3,744 messages, producing £3,103, in the corresponding month of last year. The traffic receipts for the month of February, estimated at £3,000, realised £3,009.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for May amounted to £1,557, against £1,709 in the corresponding period of last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—This company have declared an interim dividend for the quarter ended March 31st of 2s. 6d. per share, free of income-tax, payable on July 15th.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for May amounted to £22,000. From 1st January to 31st May they amounted to £103,520, and in the corresponding months of 1886 and 1885 to £100,960 and £118,000 respectively.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended May 31st amounted to £4,800.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 31st May are £3,364, as compared with £2,996 in the corresponding period of 1866.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 3rd June were £3,618, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Registered **"SANITAS"** Trade Mark.

NON-POISONOUS
COLOURLESS
FRAGRANT
DOES NOT STAIN

THE BEST

FLUID,
OIL,
POWDER,
SOAPS, &c.

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"Valuable Antiseptic and Disinfectant."—*Times.*
"Safe, pleasant, and useful."—*Lancet.*

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Head Office and Warehouse: 50, Bow Lane, Cheapside, E.C.
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Specially Low Quotations for Electric Light Cables.

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SHIPPERS AND THE TRADE SPECIALLY STUDIED.
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Secretary: LEON DRUGMAN, A.S.T.E.
Senior Instructor: H. D. WILKINSON, M.S.T.E.

THIS Establishment is now the largest and the most fully equipped School of its kind. It possesses, among recent additions, several dynamo machines and electric motors, a 6-horse boiler and steam engine, a gas engine, 42 E.P.S. accumulator cells, lathes, &c., as well as several kinds of arc and incandescence lamps and a photometer room. Both theoretical and practical training can therefore be obtained. Since its opening in 1868 more than 3,000 Pupils have passed through the School. At the end of the course of instruction, an Examination for the CERTIFICATE OF THE SCHOOL is conducted by an Examiner of high standing, unconnected with the School. New courses usually commence early in January, May, and September.

For full prospectus, terms, &c., apply to the Secretary, 12, Princes Street, Hanover Square, W.

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NOTES.

SHIP LIGHTING.—All the Great Eastern Company's steamers, except the two oldest, are now lighted by incandescent lamps.

BRIGHTON.—The Brighton Corporation have decided to extend the period for receiving tenders for the lighting of the Pavilion until Monday, the 25th instant.

"A CENTURY OF ELECTRICITY."—Messrs. Macmillan and Co. send us a copy of "A Century of Electricity," by T. C. Mendenhall, of Washington, U.S.

PERSONAL.—Mr. John Rance, jun., has been nominated by the City Guilds Institute to the vacancy offered by the Anglo-American Brush Electric Light Corporation for a pupil without premium.

LEAMINGTON.—Much disappointment is felt at Leamington owing to the inability of the contractors to complete the electric lighting of the Parade by the date of the Jubilee celebrations.

BRUNSWICK.—The municipal authorities of the City of Brunswick have decided to ask for tenders for the construction of a central electric lighting station and the supply of current to the inhabitants.

NEW BOOKS.—Messrs. Whittaker and Co. will publish early next week Mr. E. C. Robins' book "On the Design and Construction of Applied Science and Art Buildings, and their Suitable Fittings and Sanitation."

THE BELL TELEPHONE SUIT IN THE UNITED STATES.—The United States Supreme Court, at its meeting on May 27th, did not announce a decision in the telephone suits, as was confidently expected by some of the parties concerned.

THE QUEEN'S JUBILEE CELEBRATION BY ENGLISH ELECTRICIANS IN AMERICA.—The electricians of English nationality or descent now living in New York have arranged to dine together on the evening of the 21st inst., in celebration of the Queen's Jubilee.

ACCUMULATOR WORK.—The North British and Mercantile Insurance Company have determined to increase their battery plant, and Messrs. Drake and Gorham inform us that they have obtained the order for the new battery, which will consist of 53 cells, type 23L, in glass boxes.

MULHOUSE.—The town of Mulhouse has recently concluded a contract with Messrs. Siemens and Halske, of Berlin. The firm will undertake the supply of electric light, the conditions being that when the profits exceed a certain amount a fixed percentage becomes payable to the local authorities.

PROF. S. P. THOMPSON'S "ELEMENTARY TEXT BOOK OF ELECTRICITY AND MAGNETISM."—Messrs. Macmillan have just completed the issue of the twenty-sixth thousand of this excellent text-book. In the last edition the chapter on Electro-Magnetics has been rewritten and considerably extended.

FORTHCOMING SALE OF ELECTRICAL PLANT.—We would call the attention of our readers to a notice which will be found in our advertising columns of an important sale of electrical plant by Messrs. Wheatley Kirk, Price and Goulty. The sale takes place at Fulham on Thursday and Friday next week.

TELEPHONE EXTENSIONS IN SPAIN.—The Madrid *Gazette* of June 13 contains instructions for the establishment of a telephone service in the towns of Alicante and Ovieds. Tenders for the establishment and working of a line are invited up to 18th July in the case of Alicante, and for the following day in the case of the northern town.

THE JUBILEE ILLUMINATIONS.—In another column will be found some account of the electric lighting arrangements for the illuminations of the 21st inst. We have taken a good deal of trouble to render the list fairly complete up to the time of going to press on Thursday evening, but we need hardly say it by no means covers the whole ground.

THE GERMAN-EDISON COMPANY.—The report of this company (to which we alluded in our last issue) states that up to the end of 1886 the company had erected 260 installations, including 70,000 incandescent and 1,000 arc lamps. The sales of incandescent lamps for the year 1886 had amounted to 90,000, against 60,000 for the preceding twelve months.

BARCELONA.—The municipality of Barcelona has concluded a contract with the Sociedad Espanola de Electricidad for lighting some of the streets of the town with arc lamps during a period of five years. There will be 33 lamps in all, of which those which burn until morning are charged for at the rate of five shillings (nearly) per night, and those which are extinguished at 1 a.m. at the rate of three shillings per night.

THE DURHAM COLLEGE OF SCIENCE.—On June 15th Sir W. Armstrong laid the foundation stone of a new building for the Durham College of Science at Newcastle-on-Tyne, to cost from £20,000 to £25,000. Sir William, speaking afterwards at a luncheon in connection with the event, said what they now wanted was a bread-winning science, and it was owing to its absence that they were experiencing the results of foreign competition in manufacturing industry.

THE TELEGRAPH IN CHINA.—HOSTILITY OF THE PEOPLE.—The recent determination of the Chinese Government to extend their lines of telegraph communication in the interior of the country is meeting with serious opposition in some of the provinces. The workmen engaged have been repeatedly attacked, and in some cases the work has been altogether suspended. The villagers plead that the wires have a bad effect upon evil spirits, and tend to keep them awake at night.

LIEGE.—The Hall of the Conservatoire of Liege will, it is said, be the first theatre or concert room in Europe to be lit entirely with arc lamps. The lamp selected is the Pieper, of which very little has yet been seen in this country. The dynamo machines have also been specially designed for this service by M. Pieper, and are driven by a gas engine supplied by MM. Fétu and Deliege. Two of these machines give each 65 volts and 300 amperes, and there are in all 29 arcs.

BRUSSELS.—In the Rue Neuve at Brussels some shops have been recently supplied with an electric light installation by Messrs. Gerard and Co. A Kortling gas engine of ten horse-power drives a Gerard dynamo of 110 volts and 50 amperes which feed 6 arcs (system Piette) of 8 amperes and seventy-one 20 candle-power incandescents. Although the engine does not obtain power at every stroke the installation runs with great steadiness owing to the dynamos being provided with a very heavy fly-wheel.

THEATRE LIGHTING IN BRUSSELS.—Immediately after the disaster at the Opera Comique a petition was presented to the Conseil Communal of Brussels praying that the Theatre de la Monnaie might be lit by electricity. We are informed, however, that it had already been decided to do this, although it will entail extensive alterations, the side rooms of the theatre being at present warmed as well as lighted by gas. The engines and dynamos will probably be placed in the cellars of the new General Post Office, which is close by.

A SHOCK FROM AN ALTERNATING CURRENT MACHINE—Our contemporary, *Electricité*, contains an account of an acci-

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dent—happily without serious results—which occurred during some laboratory experiments with alternating currents. The machine was giving 300 volts at the terminals when they were accidentally touched by the experimenter with two fingers of the same hand. The shock was severe and was accompanied by an intense sensation of heat in the fingers, leaving a scar resembling a burn on the surface of the skin.

WILD GEESE KILLED BY LIGHTNING.—During a severe storm in California, on April 29th, a flash of lightning was observed to pass apparently right through a flock of geese which were flying high overhead. Six birds fell to the ground and were picked up dead, having evidently been killed by the lightning, although no mark was found upon them. This is believed to be the first instance on record of geese being struck by lightning while flying, ancient tradition asserting that this bird is safe from the destroying bolt of Jove.

MANILA.—The Philippine correspondent of a Madrid paper states that the Electric Light and Power Company have made a proposal to the municipal authorities to supply Manila with the electric light. The proposal provides for the erection of 1,000 incandescent and 100 arc lamps, extending over a length of 27 kilometres, the concession to last 40 years, and the municipality to make an annual grant of $40,000, besides allowing 6 per cent upon $145,000, the estimated total cost. The matter is under the consideration of a committee.

ELECTRIC TRAMWAYS IN NEW SOUTH WALES.—According to the *Colonies and India*, a rumour is current in New South Wales that the Government proposed to introduce into the colony a system of electric tramways, "and," says the journal above quoted, "it was asserted that a wealthy capitalist had taken time by the forelock and purchased the colonial right from the patentees for £10,000." We do not know who *the* patentees may be, but they may certainly consider themselves lucky individuals to get £10,000 for an electrical patent nowadays.

THE RECENT ILLUMINATION AT THE LAW COURTS.—We are requested to state that the coloured lamps used at the recent meeting of the Incorporated Law Society were Shippey Bros.' patent 8 and 10-volt low-resistance lamps specially made to run in series of 10 and 12 lamps on the Edison and Swan 100-volt circuit. This installation was successfully carried out by Messrs. Bailey and Grundy, and is good evidence of the value of a practical low-resistance coloured lamp for decorative and illuminating purposes in places where electric light plant is already installed.

MORE INCANDESCENT LAMP LITIGATION IN AMERICA.—We learn that Dr. Woodward, the inventor of Woodward's incandescent lamp, is at present travelling through the States obtaining special information with a view to institute proceedings against a number of firms for infringements of the Woodward patent rights, which are said to be in full force in Canada, Germany, and the United States of America, the former being granted in the year 1872, and the latter in 1874. This step has been taken in consequence of the recent decision of the Supreme Court of the United States in upholding the Nelson-Green patents.

FOREIGN TELEGRAMS.—In the House of Commons, Mr. Raikes, in answer to Mr. Montague, stated that he was in communication with the Telegraphic Administrations of some of the neighbouring Foreign States with regard to the arrangements which it would be necessary to make for the transmission of telegrams between this country and those States, when the concessions now held by the Submarine Telegraph Company from France and Belgium expired in 1889. He did not think that he could promise to submit these arrangements to the Chambers of Commerce, but he should be ready to consider any suggestion that they might desire to make.

THE LONDON TELEGRAPH CLERKS.—A meeting of the staff of the Central Telegraph Office was held on Wednesday night in the Lecture Hall of the Young Men's Christian Association in Aldersgate-street. Much dissatisfaction was expressed at the unfavourable replies given by the Postmaster-General to recent petitions. It was resolved that another petition should be presented to him drawing strong comparisons between the pay and privileges of the Telegraph Staff and those of other branches of the Civil Service, and asking for increased pay, extension of annual leave, and other benefits. A resolution was also passed asking that some equivalent should be granted to the clerks for their additional work on Jubilee Day, which in other Civil Service departments will be a general holiday.

ELECTRIC LIGHTING IN THE NAVY.—On Wednesday night, the 8th inst., some interesting experiments were made on board H.M.S. "Hero" at Chatham, the object of which was to afford the dockyard and naval officers an opportunity of comparing the respective beams of light thrown from two projectors, one being fitted with a Mangin reflector and the other with Ronald D. Scott's new mirror. At the conclusion of the trial the verdict was unanimous in favour of Scott's mirror, the beam from it being far more intense and of a purer white. The benefit of the latter feature was readily seen, the objects illuminated appearing in their natural colours. Mr. Scott was warmly congratulated on his success. This exhibition had been specially sanctioned by the Lords of the Admiralty owing to the favourable report received from the Portsmouth officers who have had Mr. Scott's mirror under trial.

STUDENTS' MEETING OF THE SOCIETY OF TELEGRAPH-ENGINEERS.—The third and last meeting (for the present session) of the students of the Society of Telegraph-Engineers and Electricians was held on Thursday, the 2nd inst., W. Lant Carpenter, Esq., B.A., B.Sc., chairman. After a few remarks with reference to the action of the Council of the Society of Telegraph-Engineers and Electricians in promoting students' meetings, the chairman called upon Mr. Wordingham to open the discussion upon Mr. Kapp's paper, "The Pre-Determination of the Characteristics of Dynamos." Mr. Wordingham briefly described Mr. Kapp's method, and then gave an account of that used by Drs. Hopkinson, showing some curves representing calculated and observed characteristics, after which Messrs. Rance, Hayne, Cooper, Healing, Dykes, and Lamb continued the discussion. The chairman then closed the proceedings, after a vote of thanks had been passed.

SOCIETY OF ARTS CONVERSAZIONE.—The annual *conversazione* of the Society of Arts was held at South Kensington Museum on Wednesday evening. Promenade concerts were given throughout the evening simultaneously in the North Court by the string band of the Royal Artillery, and in the courtyard by the band of the Royal Horse Guards (Blue). Two vocal and instrumental concerts were also given by the scholars of the Royal College of Music, and the various picture and art galleries, as well as the main corridors, were gaily illuminated. Between seven and eight thousand guests were entertained during the evening, the arrivals being received by Captain Douglas Galton, C.B., the chairman of the council, and representatives of every branch of art, literature, and science, as well as many social and political notorieties, were among the assembled company. The *conversazione* was continued until a late hour, it being long after midnight before the guests dispersed.

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TEMPORARY ELECTRIC LIGHTING AT CHELMSFORD.—During the Agricultural Show at Chelmsford, on the 7th and 8th inst., Messrs. R. E. Crompton and Co. gratuitously lighted the main street of the village. The lighting consisted of a circuit of about two miles of wire, as the works are some distance off. Twelve Crompton lamps were used, the power being supplied by a small Marshall engine. The insulated wires were carried down the street on ropes fastened from chimney to chimney. The lamps were also supported by ropes, and made a very effective combination with the numerous brightly coloured flags with which Chelmsford was decorated. The whole work was done in 37 working hours, the fire escape being used for fixing the lamps. Another temporary installation was put up in the show ground itself, the dog show being artistically illuminated by six small Crompton lamps giving about 500 candle-power each. By the courtesy of Messrs. Marshall this installation was driven off one of their engines.

ELECTRICAL SIGNALLING FOR MINE SHAFTS.—Considering the fact that the number of fatal accidents occurring during the ascent or descent of mine shafts has for the last six years averaged 174 per annum, it is somewhat astonishing that an efficient means of communication between the occupants of the cage and the man in charge of the winding engine was not long ago adopted. A very simple method of effecting this has recently been devised by Mr. William Armstrong, jun., of Wingate, and is now in use at the Wingate Grange Colliery, county Durham. It consists merely in placing an insulated conductor within the winding rope and making connection with a battery and bell in the engine room and with a key fixed in the cage. The circuit is completed through the sheathing of the rope. This device will doubtless commend itself to all managers of collieries and other mines, especially as the expense is, or should be, comparatively trifling. If the signalling on the bell does not meet all requirements it may, of course, be supplemented by a telephone.

THE HASTINGS ELECTRIC LIGHT COMPANY.—The fifth annual report of the Hastings Electric Light Company, just issued, includes a statement of accounts for the year ended March last. The company has now, on three circuits, 30 arc and 704 incandescent lamps, as against 27 arc, and 576 incandescent lamps at a corresponding period last year, showing a steady increase in the company's business. The sum of £3,186, the amount given up by the liquidator of the Hammond Electric Light and Power Supply Company has been placed to the reserve account, to meet depreciation on plant and machinery. The revenue account shows a gross profit of £248 on the total receipts of £1,835. Against this, however, must be charged the amount paid for interest on bank over-draft and loan, viz., £247, thus leaving a net profit of £1. 5s. 3d. The directors consider that a determined effort should now be made to pay off the over-draft, and also raise a sufficient further sum of money to enable them to extend their operations. They suggest the raising of £5,000 by debenture bonds.

TRAMWAYS—ANIMAL VERSUS ELECTRIC POWER.—A writer in the *Age of Steel* sums up the advantages of the employment of electric traction for street tramways as follows:—"1. Not so much real estate is required for the station as for the stable; nor is the location or the character of the building so much a matter of importance and cost with the former as with the latter. 2. The annual loss in efficiency of, say, one-fifth of the live stock employed, whereby twenty animals out of every hundred are sold for a song, is avoided. 3. The cost of attendance is very materially reduced. 4. There is no liability to epizooty, costly in respect of both live stock and traffic. 5. There is no likelihood of the motive power 'eating its head off' during a strike, or while idleness is enforced by any one of a number of causes. 6. The efficiency of the horse in extremely hot or cold weather is at its lowest, though it should be at its highest—which is another and the final point in favour of electricity, if we leave speed out of account." To this may be added the reduction in working cost, which practical experience is daily showing tells heavily in favour of electricity.

SEACOMBE.—A small installation of electric light has lately been carried out by Messrs. J. F. Waddington and Co., Seacombe, near Liverpool, at the works and house of W. Mosley, Esq, Springfield, Cheadle. The installation consists of a Hill patent dynamo driven from an engine in the works and run during the day to charge a set of E P.S. accumulators in the cellar of Mr. Mosley's house, the lamps being lit during the evening from the accumulator. The electroliers and fittings have been supplied by Messrs. Verity and Sons. During the winter months, when the dynamo has finished charging the accumulators it will be used to light two arc lamps of 4,000 candle-power in the works. The dynamo measures 22½in. long over all, 12½in. wide, and 22½in. high. The armature is 6in. diameter and 3½in. long. The magnets are of Nordenfelt's patent mitis metal. It is capable of giving a current of 100 to 110 volts and 20 amperes at a speed of 1,800 revolutions per minute. When wound for an E.M.F. of 50 to 55 volts it will give a current of 55 amperes at the same speed. The installation has been designed and its erection superintended by Mr. Claude W. Hill.

BURNING OF THE NEW ZEALAND GENERAL POST OFFICE—The *Melbourne Argus* of the 2nd of May gives some particulars of the burning of the Post Office at Wellington on the 28th of April. The telegraph room, the telephone exchange, the accountants and Postmaster-General's branch, the Customs Office, and the Post and Mail Offices were in less than two hours completely destroyed. The damage is estimated at between £30,000 and £40,000. There are heavy losses in records, but the telegraph documents were mostly in the safe. About £2,000 worth of telephones were saved. Everything was cleared out of the Post Office, and the *employés* began sorting mails at once in the street. The telegraph office is now located in another building. Luckily a complete set of tables and instruments designed for Napier were in store, and ready to set up at once. The Post Office is temporarily located in a shed on the wharf. The building, which is a new one, was taken over by the Government about three years ago, and cost, with fittings, £27,000. Amongst the most valuable portions of the plant destroyed was the electric light apparatus, which recently arrived from home, and was in course of erection. There was no insurance, the Government taking their own risks.

THE VIENNA TELEPHONE EXCHANGE.—A correspondent in Vienna writes us as follows:—The Vienna Privat Telegraphen Gesellschaft, the owners of the Vienna Telephone Exchanges, have just entirely reorganised their whole system, and united all their subscribers into one single central exchange, a work of great magnitude, considering that Vienna is the only large town that has underground cables, Paris having the advantage of the wonderful system of sewers for their cables. The new switch-board they have now put up for 2,000 subscribers is undoubtedly the best board at present in use in Europe, being a multiplex somewhat like the American, but with numerous alterations and great improvements, designed by the company and their clever constructor, Mr. Otto Schaffler, who also

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executed the work. The cost of this board has been very great; it is of exquisite workmanship and finish. The company succeeded in making all these alterations and putting up the new board without a single subscriber being cut off or the service interrupted even for one day, a feat very creditable to to the company's manager and engineer. Anyone interested in telephony, and desiring to see the best board, could not do better than get an introduction to the company's general manager and see the Vienna Exchange.

PROJECTED NEW SERVICE BY THE UNITED TELEPHONE COMPANY.—We understand that the directors of the United Telephone Company are taking into consideration the desirability of establishing a new service over their wires of a somewhat similar character to that at present supplied by the Exchange Telegraph Company. Those subscribers who wished to avail themselves of the service would be provided with an automatic type-writing receiver, which would at certain intervals be automatically switched on to the line wire and would deliver Stock Exchange quotations or such other information as may be arranged for. Of course the details have still to be elaborated, the United Telephone Company not having as yet finally decided to undertake the service. Provided, however, that thoroughly efficient instruments are employed, we see no reason to doubt that the service would rapidly become popular. We may add that at the offices of the company we were recently shown the instruments which were then under trial, and although it is too early to speak with confidence, there appeared much probability of their practical success. No battery or clockwork is required outside the transmitting office, and although a large number of receivers may be worked from one transmitter, yet each instrument is readily controlled and adjusted from the central station.

MAGNETISED IRON IN THE VOLTAIC CELL.—At a recent meeting of the Berlin Physical Society Dr. Gross explained his theoretical views on the heat of solution of magnetised iron, leading to the conclusion that the heat of solution of magnetised iron must be greater than that of unmagnetised. One result of these views was that a piece of magnetised and unmagnetised iron in a conducting fluid capable of dissolving the iron must give a current; this he has already demonstrated two years ago. The current in such an element as this flows across the fluid from the magnetised to the unmagnetised pole, and is independent of the nature of the magnetisation. The source of the electric current is in this case, according to the views of the speaker, to be sought for in the loss of specific magnetisation which the molecules of iron undergo as they pass from the solid to the fluid condition. Of the various solutions of salts of iron which were used in these experiments, only neutral salts of ferric oxide were found to yield a result, while the salts of ferrous oxide gave no current. The cause of this is, according to the speaker, that only the ferric salts lead to a solution of the magnets. Dr. Nichols has quite recently carried on some experiments on the heat of solution of magnetised iron, and has obtained the same experimental results, namely, that the heat of solution of magnetised iron is greater than that of unmagnetised, although he starts with theoretical views respecting the magnetic potential of solid iron and iron in solution which are diametrically opposed to those of Dr. Gross.

ELECTRIC LIGHTING BY COMPRESSED AIR-POWER.—The system of distributing power, principally for electric lighting, by compressed air, which was commenced some twelve months ago in Paris by M. Victor Popp, has met with a very fair degree of success, notwithstanding its want of economy. This has arisen in part from the fact that the motors are far less troublesome to work than gas engines, and the whole of the attendance required can readily be provided by unskilled labour. Moreover, in certain cases, for restraurant keepers more especially, the refrigeration produced by the expansion of the air is regarded as a feature of very considerable value. The total efficiency of the compressed air plant is believed, however, not to be much higher than 10 or 12 per cent. At Paris the works are established at Saint-Fargeau, and the conduits are carried to a total distance of 10 kilometres. It is estimated that, after allowing for the loss of power due to the heating of the air during compression, at least 50 per cent. of the available pressure is lost by leakage by the time the extremity of the line is reached. After this we have to allow for the efficiency of the air engine, and of the dynamo. However, as the cost of producing one horse-power at Saint Fargeau does not exceed 6 to 7 centimes per hour, and as M. Popp receives as much as 70 centimes per horse-power hour in the Chausée d'Antrim, a margin of profit would be left, even with a 10 per cent. efficiency. We understand that the offices of the journal *Le Figaro* will shortly be lit with 400 lamps by this system.

ELECTRO-MAGNETIC TERMINOLOGY.—We would call attention to the fact—which will no doubt be welcome to the majority of our readers—that in the present instalment of Mr. Oliver Heaviside's remarkable investigations on "Electro-Magnetic Induction and its Propagation," he repeats and classifies the new terminology which he has been employing in this series of papers. This terminology will no doubt gradually win its way into general acceptance, and has, indeed, already been adopted by several of the leaders of the scientific world. The want of an adequate and settled form of nomenclature to express certain electrical phenomena whose importance has only of late received recognition has been forcibly demonstrated by the fact that scarcely any two writers have made use of the same word to express even the more practically important of these phenomena. For instance, the effect produced in a circuit traversed by an alternating current which tends to reduce the current, and which is a function of the resistance, the inductance (self-induction) and the periodic time of the alternations, has been called by various writers "apparent resistance," "virtual resistance," "choking effect," "induced resistance," "effective resistance," and half a dozen other names, all more or less objectionable. This Mr. Heaviside appropriately terms the "impedance," and he incidentally throws out a hint to Messrs. Sharp and Kent, and others of our practical men, to make use of the term "impeder" (accented on the second syllable). Then, again, the inductive capacity of a conductor is termed the "permittance"—a word which carries its own recommendation upon the face of it. We may also call attention to Mr. Heaviside's disapproval of the use of the term "magnetic resistance."

COST OF ELECTRIC LIGHTING AT DRESDEN.—The experimental electric lighting installation at the old town Municipal Buildings, at Dresden, has now been in operation long enough to give reliable data with regard to its cost and general efficiency. The installation has been carried out and maintained under the supervision of the manager of the gasworks, who has recently drawn up a report and enumerated his principal conclusions to the *Journal für Gasheleachtung*. The requisite power has been obtained from a constant current dynamo made by Messrs. Siemens and Halske, driven by a gas engine and placed in a ground floor room at the back of the buildings. The light was obtained from 93 incandescent lamps, afterwards increased to 94, and consisting partly of 16 candle-power Edison lamps, and partly of 25 candle-power Siemens lamps. During the first three months, from the 1st of October

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to the 31st of December, 1885, 55 lamps on an average were in use for 77 days; from the 1st of January to the 31st March, 1886, 59 lamps for 74 days; and from the 27th of September to the 31st of December, 1886, 77 lamps for 81 days. The cost of maintenance per lamp was found to be for the first period £3. 6s. 10½d., for the second £2. 3s. 3½d., for the third £1. 15s. 1d., and, allowing for the rental value of the machine room, and 8 per cent. for interest on capital and for depreciation, the amounts were estimated at £5. 6s. 4½d., £4. 6s. 3d., £2. 19s. 9d. respectively. The relatively high cost during the first three months was chiefly due to the various alterations and improvements which were found to be desirable, and also to the almost exclusive use in the first place of Edison lamps, which were found to require a relatively high expenditure of energy entailing a correspondingly high cost. The municipal council of Dresden are thoroughly satisfied with the results already obtained, and they have resolved on a further extension of the installation.

THE FRENCH TELEGRAPH SERVICE.—Some singular allegations have recently been made with reference to the French Telegraph Department, which, if true, would show that the *employés* have far more serious grounds for dissatisfaction than have ever existed in the English service. However, we are unwilling to believe, without further evidence, that the internal administration of any department of the French Republic can be so rotten as here represented. We quote the following from the *Evening Standard*:—"The *employés* of the Posts and Telegraph Department in France have a grievance against the late Minister of that Department, M. Granet, to which they venture to give utterance now that he is no longer their superior. It appears that M. Granet had a large number of personal supporters and *protégés* to oblige—and in this he in no way differed from the majority of French politicians who take office. To oblige them, however, and to provide them with snug berths he utterly disregarded—so it is complained—the most elementary rules of promotion; and whilst old clerks were unable to obtain a modest rise of a hundred francs on the score that there were no funds disposable, thirty-seven, or more, supernumeraries were made permanent clerks, with good salaries, and without passing the necessary examinations. It is related of M. Granet that being anxious to be civil to a Radical journalist, and there being no vacant post for him, he created one of chemist, though the man of the press admitted he knew nothing whatever about chemistry, and could not even study that branch after his appointment, because it would interfere with his newspaper occupation. He could, however, and did, draw his salary—as this did not interfere with what he had to do on the press. Nearly a thousand signatures of postal and telegraph clerks are affixed to the petition that has been presented to the new Minister of their department, begging that an investigation into the matter may be made. If, as is asserted, salaries to the amount of 70,000fr. have been irregularly bestowed by M. Granet on his *protégés*, that gentlemen will await, we should think, with some misgivings the result of the inquiry—should one be held."

BOSTON, U.S.—The following description of a new central lighting station in this town is given in the New York *Electrical World*:—"The Citizens' Electric Light Company, of East Boston, on Monday, May 16, occupied its new station on the site of the one burned March 4. The new building is of brick, only one story in height, but, owing to the conformation of the ground, is nearly 30 feet from floor to roof inside. The floor is of massive timbers, the spaces between which are filled solid with coal ashes, planked with 2 inches of spruce, and crossplanked on top with narrow, hard pine flooring. The roof is supported by heavy trusses of hard pine, and is covered with the best of Easton slate. The boiler room is completely isolated from the engine and dynamo room by brick walls running to the roof, the only communication between the rooms being through a doorway closed by an iron door. The circuits are led into the building through hard pine timbers built into the wall, glass floor insulators being set into the hard pine, and heavy Clark wire running from the outside of the building to the switch-board directly beneath the point of entrance. The plant consists of three American dynamos, two of 50 lights capacity each, and one of 25 lights, belted direct to the engines—one New York Safety Steam Power Company's 60 horse-power, and one Armington and Sims' 50 horse-power—with Charles L. Ivison's patent adjustable link belts. The boiler is of 100 horse-power, made by E. Hodge and Co., of East Boston, and is fed by a Davidson steam pump, through a National feed-water heater. It is set with the Jarvis patent furnace, and a mixture of Cumberland coal and screenings is used for fuel. All the appliances are of the most approved modern design, and no finer or more convenient station for the capacity can be found. The switch-board—furnished, as is all the electrical plant, by the American Electric Manufacturing Company, of New York—is a model of compactness and simplicity, and enables the man in charge to handle the circuits with great ease, and to make any desired change or combination without stopping the dynamos. This company has a large and prosperous business in East Boston and Chelsea."

THEATRE LIGHTING IN PARIS.—The terrible disaster at the Opera Comique has led in France to a very wide-spread feeling that gas should be at once and finally excluded from the interior lighting of theatres and places of public amusement. This feeling found expression at the last meeting of the Municipal Council in a resolution proposed by M. Emile Richard, and for which urgency was immediately voted. The resolution was couched in the following terms:—"Considering that the employment of gas in the lighting of theatres and concert rooms constitutes a permanent danger to the public, the Council determines that a delay of three months is allowed during which the theatres and places of public amusement of Paris are to substitute throughout their establishments the electric light instead of gas light. At the end of the aforesaid period the public will be forbidden to enter all buildings of this description which have not complied with the terms of this order." In the meantime, the regulations drawn up by the Prefecture of Police for the installation of electric light are allowed to remain in all their original crudity. Our readers will find a transcript of this extraordinary edict in our issue for March 25, 1887, and it will be a matter of some interest to see how the Paris theatres are to be extricated from the predicament in which they are undeniably placed. The Municipal Council will almost certainly confirm the resolution for the compulsory adoption of the electric light, while the unquestionably impracticable character of the police regulations amounts to little short of a prohibition of its use. No doubt the electrical industries in Paris will make the strongest possible protest against the continuance of these absurd restrictions; but in the meantime the police are evidently determined to enforce the edict in all its rigour. The little theatre of Chatelet was closed last week by order of the police for non-compliance with the regulations in the matter of the Jablochkoff candles, with which it has been lit for the past two years. We do not know in what precise point the Chatelet installation was in fault; but it is scarcely probable that the actual risk from the use of electricity could in any case have been comparable with that which exists in any theatre lit by gas.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 28.)

In the curve given in the preceding chapter a certain value for h was indicated at which maximum work would be performed by the machine, and this was stated to be applicable to one size only.

Although the above restriction is actually imposed by the mathematical facts, the necessities of the designer, who must have some rule in fixing the value of h, and the many simplifications attending its removal, well justify us in treating the depth of winding as a simple linear function.

The best average ratio, β, may be found by calculating such a curve as was given in Fig. 9 for the most usual sizes. We then have in the expression for E,

$$E = Z_1 \,.\, n \,.\, N \,.\, 10^{-6}$$

Taking the radius of the armature R as representing the linear dimensions of the machine, we have $Z_1 \propto R^2$ when the density σ is constant, also under like conditions the magnetic resistance of the system $\propto \frac{1}{R}$.

$$p_1 = Z_1 (K_1 R_A + R\alpha).$$

$$\therefore\ p_1 \propto R.$$

In a similar manner $z = \frac{p_1}{\rho} \propto R^2$.

$$\therefore\ Z_1 + z \propto R^2.$$

But $$Z_1 + z = \frac{p_2}{K_2 R_F};$$

$$\therefore\ \frac{p_2}{K_2 R_F} \propto R^2;\ \text{also } K_2 R_F \propto \frac{1}{R}$$

$$\therefore\ p_2 \propto R; \qquad \text{thus } p_1 + p_2 \propto R.$$

The total exciting power is thus a simple linear function; but this would not be the case unless h were expressed simply as inversely proportional to R.

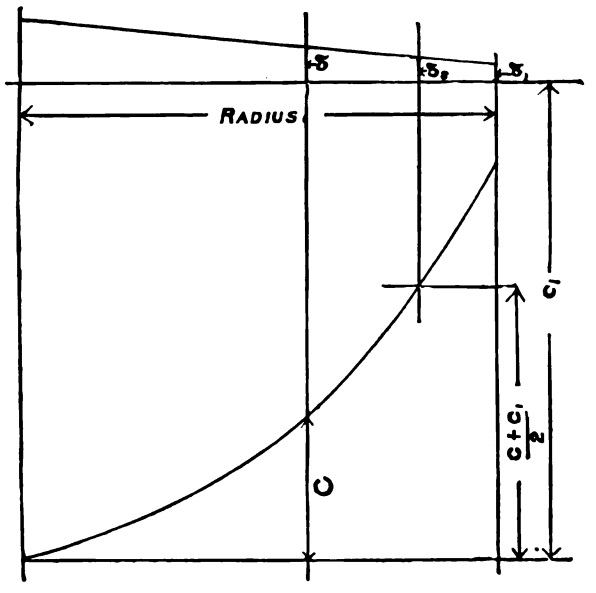

FIG. 10.

The original variation for the output with the linear dimensions may also here be incidentally verified.

Keeping N constant, and expanding the machine in all parts whilst maintaining a constant peripheral velocity, $n \propto \frac{1}{R}$ and $Z_1 \propto R^2$, thus $E \propto R$; under these same conditions it was shown in the previous chapter that $C \propto R^{\frac{3}{2}}$, thus $E\,C \propto R^{\frac{5}{2}}$.

Similarly, keeping n constant, $E\,C \propto R^{\frac{7}{2}}$, which were the two results obtained from the original equations.

Since P, the exciting power, $\propto R$, and the current, $C \propto R^{\frac{3}{2}}$, it is obvious that the length of the magnet cores must vary as $R^{\frac{2}{3}}$; the product $C\,l$, to which P is proportional, where l is the length, will then vary as R.

The fact that this variation in the length of the cores will destroy the equation for the magnetic resistance introduces a differentiation into this problem, but one so unimportant that it may be safely neglected.

It is frequently found convenient to make the depth of winding at the inner radius of the armature considerably greater than on the outside. In those machines in which the sides of the armature are embraced by the pole-shoe it then becomes somewhat troublesome to calculate the mean value for δ.

The following simple geometrical construction will be found very useful in making this determination. The radius R is first set out horizontally; on this the two verticals δ and δ_1 are known, and the line joining their extremities is accordingly drawn and produced to the origin. Then, since the magnetic conductivity of an air space is proportional to the ratio

$$\frac{\text{cross section}}{\text{length}}$$

the elementary conductivity will be represented by

$$\frac{R}{\delta}$$

the values of which are plotted on the lower curve. The point of mean conductivity between the values c and c_1 is projected to the upper figure which gives the corresponding value δ_s, which may be taken as the mean length of *side* air space. The true mean is then found at once from the relative areas of the top and side surfaces of the shoe.

Hitherto it has been assumed that the full E.M.F. calculated from the speed and strength of field could be obtained. This, however, is not strictly true, excepting under ideal conditions.

In the first place an error, which, however, is really infinitesimal in ordinary machines, is made in the assumption that the E.M.F. is expressed by such an equation as

$$E = Z \,.\, n \,.\, N \,.\, 10^{-6}$$

which does not give any indication of the integration which would be required to express the sum of the different velocities of line cutting of the various coils. The reason that such simple treatment is justifiable is because in ordinary machines the coils are so close together, side by side, around the armature, that practically the E.M.F. in each half of the armature is the automatic integral of every different velocity of line cutting, and the error is in reality only that which results from treating the field as uniform throughout the angular space occupied by a single wire. Although practically correct for ordinary dynamos, this equation could not be used for such machines as the Brush arc light dynamo.

There is, however, a real modification in the E.M.F. due to self-induction. Self-induction generates an E.M.F. in a circuit by the magnetic disturbances due to fluctuations of current within itself, that is to the increase or decrease in the number of its own lines of force. Since every circuit contains at least one closed loop, it is evident that the magnetic lines sheathing the conductor must in their formation or extinction produce a corresponding increase or decrease in the number of lines contained therein. The E.M.F. thus generated is, by Lenz's law, counter to the impressed E.M.F., and is measured at any instant by the rate at which the lines are increased or diminished, and the mean E.M.F. during the time T, in which the total number of lines are enclosed or extinguished, is the surface integral of all the values taken at each element of the time T, divided by T.

The above integration can only be made when the curve of the velocity of change is known, and this depends entirely upon the conditions of the circuit.

The reversal of current at the collecting points on the commutator is accompanied by (1) an extinction of the lines due to the exciting power of the particular coil, or section of coils, under reversal, and (2) by the birth of a new set of lines in the opposite direction; both these changes oppose the flow of the impressed lines, and may therefore be looked upon as actual lines flowing in the opposite direction.

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Viewing the matter in that light and neglecting the effect of hysteresis, it would seem that the same exciting power would be necessary to cancel a line of force as was required for its production. The fact, however, that a large proportion of these lines must close through the air space just over the collecting point would vitiate the above reasoning, and we are therefore unable to state in numerical terms the magnetic resistance offered to the passage of the back lines. The same difficulty is confronted on endeavouring to express the numerical value of the average current which excites these lines, because the logarithmic function which gives the curve of the stability of a current in terms of the resistance and time also involves the coefficient of self-induction of the circuit. This coefficient is merely the number of lines which would pass through the circuit with unit current, but, with our present knowledge, it cannot be determined direct from calculation.* We know, however, that Z_L, the back lines, can be expressed as the product of the average current into the number of coils through which it is passing, divided by the magnetic resistance of the system. Now the number of coils engaged in reversal is proportional to $\frac{N}{S}$, where S is the number of parts in the commutator; thus with constant speed the counter E.M.F. $\propto \frac{N C_a}{S R_L}$, where C_a = the average current, and R_L = the magnetic resistance to the back lines. It will be seen at once that the above expression vanishes at saturation point of the armature core, as R_L would then be infinite; the importance of making the commutator with a great number of segments is also apparent.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—XVII.

BY J. SWINBURNE.

Exhausting Continued.

The lamps to be exhausted are sealed to a branch tube, so that three or four are pumped at the same time. The sealing-on tubes left on the lamps by the glass blowers should have thick walls, otherwise it will be difficult to seal the lamps on. To make a good joint the lamp is held in a slanting position, so that the end of the sealing-on tube touches the end of the branch tube at one side. The tip of the flame of the blowpipe is then directed so as to play on the whole of the edges of both tubes till the glass begins to fuse. The lamp is then moved into a vertical position so that the two tubes are sealed together; the lamp is then raised so as to draw the joint out a little. This is necessary, otherwise the joint would probably crack. It requires some little practice to seal on nicely. A beginner may blow into the joint by means of a piece of rubber tube from his mouth to the branch tube. There is always an extra branch left, and when all the lamps are sealed on this is drawn out to a fine point. When the lamps are finished this fine point is broken off. If the vacuum in the pump were broken roughly by breaking off one of the ends of the branch tubes, for instance, the rush of air would take the phosphoric anhydride round into the pump. This extra tube can then be used for a rubber mouth tube. Before starting the pumps care should be taken that the joints are good. If they leak much it will of course be noticed at once, but if there is a small crack it may be found out by the pump taking a long time and not finishing the lamps properly even then. If a small crack is discovered after the pump has been running for some time it may be touched with the finger wet with silicate of soda. If the joints are clumsy the lamp may crack off, and if this happens when the pump is working the phosphoric anhydride will be taken round into the pump, and the whole will have to be dismounted and cleaned. Between the branch tube and the pump one or two phosphoric tubes are inserted to dry the air from the lamps. The blowpipe used for sealing on is the cause of much moisture, and blowing into the branch tube in sealing causes more. The bulbs are also generally wet inside when they come from the glassblowers. When the lamps are sealed on and the pump started, the air taken down by the pump shafts greatly diminishes, till there is a rattling noise. If the pumps are now allowed to run for a long time it will be found that the vacuum after a certain point does not seem to improve. This is because the inside of the bulbs still contain a great deal of air and moisture which is condensed on the glass and in the carbon. This comes off gradually, and will, in fact, continue to come off even after the pump has been running for a week. This difficulty is overcome by heating the lamps or running them on the pumps. Leads are arranged so that the lamps can be run a little brighter than their normal power. The writer has used a water resistance for each lamp, so that each could be brought to the right temperature. The water resistance consists of a tin bottle with movable wires through the cork dipping into a solution of caustic soda. In order to heat the glass thoroughly the heat is kept in as much as possible by means of asbestos caps put over the lamps. The lamps and the branch tubes may be placed inside a sort of oven of asbestos or some such non-conducting material. It will be found that on heating the lamps the pumps will at once begin to take down air again, and the rattling will cease for some time. After a little it will again commence, but soon the pump will take down no more air. The lamps are then finished and may be sealed off.

The practice of running the lamps on the pumps is almost universal among lamp makers; but the writer thinks it is a mistake, and has long ago abandoned it. It is generally supposed that the gas which appears when the lamps are run on the pump comes out of the carbon; but it seems probable that practically the whole of it comes off the glass which is heated by the carbon. Carbon, when it has been well flashed, has, as already stated, very little power of occluding gases, this power having been destroyed at the high temperature needed for depositing hard grey carbon. It is, of course, well known that glass condenses considerable quantities of gas on its surface. The writer has made numerous experiments, and finds that if the lamps are heated enough by external means it is quite unnecessary to run them on the pumps. If the vacuum of one of these lamps is tested after it is sealed on the pumps it will not be found to alter when the lamp is run. If the joints are made by deposition of carbon under benzole, or of merely carbonised cement, they may contain some hydro-carbon, or may occlude gas, and it may then be advisable to run the lamps on the pumps. In the writer's lamps the joints are made by deposition from gas, so that there are no such troubles.

Though the Sprengel pump is generally regarded as infinitely superior to the Geissler for high vacua, the writer believes this to be a mistake. Nevertheless if a Geissler pump is badly designed or badly worked, its results are not nearly so good as the Sprengel pump. Before arriving at this conclusion, the writer tried many experiments. He made an experimental pump, consisting of a Sprengel and a Geissler connected to the same lamps. In all cases the Geissler gave the best vacuum. The Sprengel could be worked till it took no more air down, and the Geissler would always continue to take out air. Many different Sprengel shafts, with jets of different sizes, were tried to make sure, but the result was always the same.

To get such results from a Geissler pump two things are necessary. The bulb of the pump must be kept perfectly dry, and the valve must be so designed that it is opened with the least pressure. Figure 16 is a diagram of the writer's pump. It consists of a bulb, A, on a long stalk, G, which passes through an airtight stopper nearly to the bottom of the bottle B. The bulb is drawn to a point at the top, and the tube is enlarged into the little bulb at C. It is again contracted where it joins the valve tube D. From the top of D there is a tube to the globe E, which communicates with the vacuum tube F; H leads to the phosphoric tube I, and J leads to the branch tube on which the lamps are sealed.

* Recently Profs. Ayrton and Perry have constructed a most interesting instrument, called by them secohmmeter, for measuring co-efficients of self-induction. There would be some difficulty in using it in connection with dynamos, however, on account of the necessity of obtaining the proper working condition of saturation.

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Ten or twelve pumps are mounted on each table. The pump tables are long and narrow, and of a convenient height for the operator. The tables are away from the walls, and the pumps are fixed to the backs. This is to make them easy of access for repair. The pumps are worked by girls, but, though it is easy to train girls to work the pumps well, it is impossible to get them to understand the principle enough to repair their own pumps. The repairing and replacing is therefore done by men, or preferably boys, but each pump must be accessible without interfering with the working of the other pumps. Each girl looks after five or six pumps. A careful lad can keep twenty or so in order. A set of pipes runs along the front of the table for gas, compressed air for raising the mercury, compressed air for the blowpipes, and vacuum for starting the pumps. The operator has then the whole under control from the front. When the lamps are sealed on, the pump is started by opening the tap L, which is connected with the vacuum pipe F. Communication with

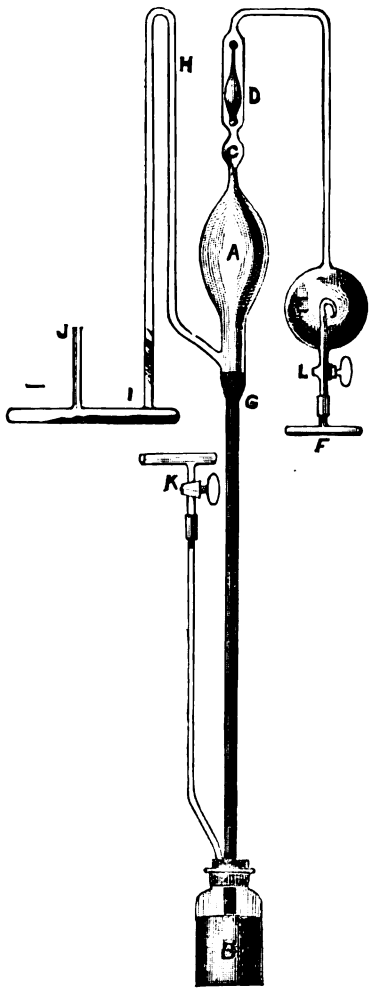

Fig. 16

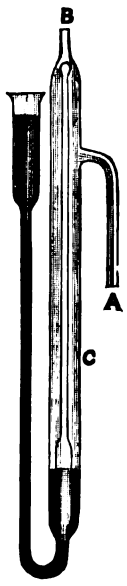

Fig. 17.

E is made through a bent tube drawn fine. This is bent so that any globules of mercury that are drawn over into E may not be taken into F. It is small, so that there is not a sudden rush of air through the phosphoric tube, and so that the vacuum in F is not too much reduced, as if the vacuum in F were broken and some other pump on which the lamps were nearly finished were at the moment connected to F, the vacuum might be spoilt, as the valve in D will not always hold against pressure. Though the tap L is shown diagramatically just under E, it is really at the front of the table. When the vacuum in the pump and lamps is about half an inch the tap L is shut and K is opened. This communicates with the intermittent air pressure. When A is exhausted the mercury rises to the level shown in the diagram. When the pressure comes on it rises quickly past the mouth of the tube H till it comes to the first contraction. The pressure is enough to raise it about half-way up D. It therefore rises slowly to this point and the valve floats in it. The pressure is then removed, and the mercury falls; but the valve closes before the mercury has all run out of D, so that the valve is sealed by mercury. When the mercury uncovers the end of H air from the lamps runs into A. When the mercury rises again this air is accumulated in the little bulb C till it has enough pressure to lift the valve and bubble through. It takes little to lift the valve, as it is exhausted on both sides. The little bulb C is to prevent the mercury rising and hitting the valve with a sharp tap when the exhaustion is nearly complete. If it were allowed to do so, any air that there might be would be compressed into a small volume at the moment the valve was opening, and would then stick against the glass instead of being carried through. As it is, the contraction below C breaks the shock due to the inertia of the rising mercury, and it then rises slowly as there is little available pressure. The whole success of the pump depends on the valve arrangement. The great thing is to avoid water vapour; it condenses against the walls of the little bulb C, and remains there till the valve is closed. It then expands again and fills A. If the vacuum in E is kept very good, water vapour will always have enough tension to lift the valve. When the vacuum in the lamps is nearly complete the pump will only take out a very small bubble of air each time. When the valve rises it does not rise straight, and the lower end follows the curved side of the valve tube a little way and then leaves it, and it leaves the air sticking against the side. Thus the air taken out by each stroke can be seen. The pump never shows a perfect vacuum—that is to say, it always takes out some air every stroke.

When a Sprengel pump stops this pump shows a vacuum of about one in a million, and if worked for some days it still shows a pressure of about one in five millions, according to the usual determinations of vacua. In starting a new pump it is often necessary to heat the shank G by means of a Bunsen burner, as bubbles are otherwise apt to come off the glass, and rise and spoil the vacuum. The phosphoric tube I is made long at one end for ease in refilling. When the phosphoric anhydride is used the tube is replaced. The long end is opened, and the tube washed out, dried, refilled, and sealed again. This is repeated till it gets too short.

A little cotton wool may be put in the tube H, so that if the lamp breaks off the air does not carry the phosphoric anhydride round into the pump with a rush. The compressed air is supplied by a small air compressor, which delivers into a reservoir. This reservoir is connected with the various pumps through a three-way tap, which is worked by a sort of adjustable cam arrangement, driven by any convenient shaft. The tube K is thus alternately supplied with compressed air, and connected with the atmosphere. The time the pressure is on is regulated by the cam arrangement, and the pressure is regulated by a sort of blow-off valve, which is shown in Fig. 17. The vertical chamber C is connected by the tube A, with the pressure reservoir in the engine room. The pressure is balanced by the head of mercury in the other limb. If the pressure is too great, a glass float connected with the glass rod and valve falls and opens the outlet B. The compressor is made to give rather more air than is needed, so that the pressure is controlled by the valve. This arrangement is placed in the pump room, so as to be accessible. The pressure is regulated by the amount of mercury.

The writer's pumps have the advantage of extreme simplicity. They are easy to make; in fact, they can be made by lads, no part demanding skilled labour. They are easily worked, and the mercury is kept clean; in fact, it never seems to get the least tarnished, and a pump goes on for months without needing cleaning. The lamps are not run on the pumps, but are strongly heated externally. The branch tube and the lamp are placed inside a sort of oven. This consists of a cover made like a large tin top hat. The walls of this are double, the space between being packed with slag wool. Each cover is suspended from the ceiling, a counterweight and pulley being arranged so that when the lamps are sealed on the cover is drawn down over them. It then sits on a tin base, which is

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made in the same way. The cover has three short legs, which keep it half an inch off the plate. The tube J is led so as to come in under the cover and rest on the plate; it then rises to the lamps. There is a hole in the centre of the plate, through which a Bunsen burner passes, the plate being raised from the table so that the top of the burner is a little above the top plate. There is a small hole in the top of the cover. A very small flame heats the lamps strongly enough, and so even and gradual is the rise of temperature that exhausted lamps will sometimes collapse gradually without breaking. The writer has seen lamps in which not only the thin parts of the globe were folded into contact, but even the thick ends where the stems were sealed in were flattened. Generally, however, lamps inplode, or burst inwards, when too strongly heated on the pumps.

LITERATURE.

Factory Accounts: Their Principles and Practice. A Handbook for Accountants and Manufacturers. By EMILE GARCKE and J. M. FELLS. [Crosby Lockwood and Co., 1887.]

Writing with some amount of experience with regard to accounts, we must confess that this work of Messrs. Garcke and Fells seems to us to be one of the most important ever published dealing with these matters. These gentlemen have treated the subject from the standpoint of the factory, as practical men speaking to practical men, and not, as has been too often the case, as schoolmasters to schoolboys. The authors give us valuable information relating to business accounts. The schoolmasters give information to enable the schoolboy to pass an examination, the examiner generally knowing about as much of the practical work as the schoolboy himself. It will obviously be impossible without writing a mongraph on the subject to deal at length with a work of this kind. We presume the text of the author would be to show that in all factory accounts there must be independent checks for every transaction, and that these checks must be such as cannot be tampered with to the detriment of the owners. The sermon they have preached upon this text is an admirable one, and the lessons to be derived are valuable. Specimen headings for the various books are given. Each point as it arises is clearly considered, and its bearings upon the main question shown. We are quite sure that there is scarcely a limited liability company in existence which keeps its accounts satisfactorily. The temptation to add to capital and to minimise depreciation is a phase of human nature that so long as companies exist will not be found wanting. Messrs. Garcke and Fells very clearly lay down the features of business which determine depreciation, and they insist on periodic valuations. We could wish that every manager or managing director of every company would carefully consider all that has been said by the authors, and as their views seem adapted to promote financial soundness, we trust they will be more extensively followed in the future. Whatever influence this book may have, the commercial community is under a heavy obligation to the authors for having so carefully analysed the system of factory accounts and so clearly put the analysis before the public.

ELECTRIC LIGHT ILLUMINATIONS FOR THE JUBILEE.

Although the electric light will make a fairly conspicuous show in London on the night of the Jubilee, yet, owing in large measure to the comparatively short notice which has been given, many firms have already had to close their books, having exhausted their available stock. The following account will, we believe, be found to include the most important of the installations which are to be carried out within the metropolitan area:—

Conspicuous among the illuminations in the City will be that of the Stock Exchange, which has been entrusted to Messrs. Woodhouse and Rawson. The front of the building facing Broad-street will be brilliantly lighted up by rows of incandescent electric lamps following the outline of the structure. Above these will be placed a couple of devices forming the letters "V. R.," composed of lamps of variegated colours, the whole being crowned by two arc lights of intense brilliancy. The same firm have also undertaken to illuminate the outside of the warehouse of Messrs. Fred. Huth and Co., of Tokenhouse-yard. A similar idea will be carried out here, the outline of the building and portico being followed by rows of incandescent lamps, while each side of the doorway will be flanked by the letters "V. R," formed of coloured lights. Messrs. Woodhouse and Rawson have in hand several other installations of smaller dimensions at private residences in the West End.

Messrs. Laing, Wharton and Down will testify to their own loyalty on the occasion by an illumination of arc lamps in front of their offices on the Holborn Viaduct. In consequence of the drain upon their plant by the requirements of the American Exhibition, which this firm are now lighting by electricity—they have been obliged to refuse many orders for installations in different parts of the City. This firm are making arrangements for illuminating the *façade* of the Temperance Provident Insurance Offices at London Bridge, on which twelve powerful arc lamps will be displayed. They have likewise contracted to supply the new premises of Messrs. Pears, soap manufacturers, in Oxford-street, with ten lamps of the same kind.

Messrs. R. E. Crompton and Co., of Queen Victoria-street, have secured some orders for minor installations in the City and elsewhere. They have also supplied the following orders in connection with the illuminations:—One dynamo and six arc lamps for use at Dorking; one dynamo and six arc lamps for use at Hampstead; 25 arc lamps to Messrs. Verity for use on a triumphal arch at High-street, Kensington; 10 arc lamps to the Edison-Swan Company; and 50 incandescent lamps for Messrs. Barclay's bank. The majority of the arc lamps will be of large size, giving from 5,000 to 11,000 candle-power. We understand that Messrs. Crompton have found that the demand for arc lighting has far exceeded their expectations, and it has not been possible to accept all the orders received.

It will, perhaps, be in the region of clubland, however, that sightseers will find most to gratify the eye in the matter of outdoor lighting. There the most extensive preparations are being made to give unstinted expression by electric and other illuminants to the depth of the national attachment to the Throne. The members of the Junior Carlton Club, who of recent years have claimed an almost exclusive monopoly of this particular virtue, are determined for once to out-distance their neighbours in point of light and leading, for they promise to have one of the largest, if not absoletely the largest, individual electric light installation in the metropolis. Messrs. Verity and Sons, of Covent Garden, have been commissioned to carry out the work, which will consist, among other attractions, of no less than 28 arc lamps of 2,000 candle-power each, distributed artistically over the side and front elevation of the building. The same firm have also the contract for lighting the Grand Hotel at Charing Cross, for which they have designed some pretty and appropriate devices in incandescent lamps. They have besides booked a number of smaller orders for private houses in and near London.

The new Gülcher Electric Light and Power Company have had an accretion to their ordinary business on account of the Jubilee celebration; but they have chiefly confined their attention to the execution of provincial orders, amongst others being installations for Southampton, Herne Bay, and Ashford. Besides supplying the Crystal Palace Company with thirty arc lamps of 2,000 candle-power for lighting up the grounds, the Gülcher Company are responsible for the electrical apparatus which is to be used for the firing off of a salute of twenty-one guns from the band stand in front of the Palace on the arrival of the Prince of Wales, who has promised to attend the rejoicings there. The company have also the contract for the illumination of Winchester Cathedral with a 10,000 candle-power Gülcher projector.

The Anglo-American Brush Corporation are providing the following:—At the Institution of Civil Engineers, Great George-street, an inscription covering the whole front of the building, formed by over 500 ten candle-power glow lamps. This will be a complete temporary installation, there being no available engine or dynamo on the premises. At the Drapers' Hall, Throgmorton-street, an illuminated inscription and tracing of some of the lines of the building in lines of light will be shown, some 160 glow lamps being used. These will be taken from the permanent installation supplied to the Drapers' Company by the the Anglo-American Brush Electric Light Corporation last year. Lord Thurlow's house in Chesham-place will be similarly illuminated with about 120 glow lamps, and Mr. Lampson's house in Pont-street, Chelsea, with about the same number, the current in both these cases being supplied from permanent installations supplied by the Anglo-American Brush Electric Light Corporation.

Messrs. Faraday have been for some time busy in responding to the many demands made upon them for electric light decorations for a number of important buildings in the West End. Messrs. Collinson and Lock's establishment in Oxford-street, as well as the Royal Institution, Albemarle-street, have been each fitted with electric lighting apparatus, and the latter especially promises to give a display worthy of its name and traditions.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE JUBILEE OF THE TELEGRAPH.

PRESENTATION PORTRAIT OF FARADAY.

Our readers know that the present year of grace is not only the Jubilee of the accession of the Queen, but also of the introduction of the Electric Telegraph. The most prominent Electrician of the period—we might say of the century—was Michael Faraday, and we purpose giving with our next issue (as a Supplement) a Steel Portrait Engraving of this illustrious representative of English electrical science.

OUR AMERICAN COUSINS.

The meeting of the British Association on the American continent in 1884, and more particularly the visit which many of the members paid to the States on that occasion, have been not merely conducive to good relations between kindred races but productive of fruitful results to the community of science. In May of that year the American Institute of Electrical Engineers came into existence, and it was honourably represented at the Association's gathering at Montreal in the following August. A month later the Association furnished representatives to attend the Electrical Exhibition at Philadelphia. There is little doubt that from one of these points the society which in America corresponds nearest to our Society of Telegraph-Engineers and Electricians practically dates its active career; and equally probable is it that the English visitors contributed to make its beginning a hopeful one. At all events, the two societies are working on similar lines and for the same ends; and we may confidently assure the younger society of the sympathetic good wishes of its elder cousin in England. A more substantial proof of goodwill would, we have no doubt, be forthcoming should the American Institute find it necessary to ask for it in the shape of subscriptions to their building fund—or to speak in the American manner, their "Permanent Quarters'" fund. If we hope that no such appeal may be necessary it is simply because we should prefer to see the money subscribed on American soil in proof of America's sincerity in patronising—to quote the native language again—"the development of Electric Arts."

The position of the British and American societies is identical in respect to their indebtedness to an external society—that of the Civil Engineers in both cases—for their places of meeting. The former, it is true, possesses a separate establishment liberally endowed, and already possessed of offices and reading room, with probably the finest electrical library in the world. At these premises, too, are held the Students' meetings, which have been only recently started, although the admission of students to the privileges of the Society dates many years back. We incidentally mention this fact for the benefit of our American friends, some of whom seem to have been much exercised on a point of dignity by a proposal to add to their roll a class of "Juniors." These juniors are spoken of disparagingly as boys who have no serious interest in the objects of the Society. We are naturally diffident in offering a common-sense suggestion to our hard-headed transatlantic relations, but it does seem to us that were they to call these "boys" *Students*, and take steps to make them live up to it, the question of dignity would be satisfactorily disposed of, as it has been here.

Except for the purposes above named, however, the English Society of Telegraph-Engineers and Electricians has been dependent during the whole of its lifetime, dating from 1878, upon the generosity of the Institution of Civil Engineers for the use of their splendid theatre, in which the Society's fortnightly meetings during the spring and winter months of the year are held. The American Society, on the other hand, although only three years old, aspires already to own a separate "house" all to itself, and the cost of which is to be $30,000. The sum is not extravagant, and the charge for maintenance, exclusive of personal service, is estimated at only $2,000. Of the prime outlay it is thought that a third can be collected, the remaining two-thirds being borrowed at 4 per cent. interest, which is included in the figure mentioned for maintenance. The scheme is a bold one, considering the present numerical strength of the Society; but the Council are confident of largely augmenting its members, and more especially when it enjoys the advantage of possessing an establishment of its own "where men engaged in the same pursuits could freely interchange ideas and afford each other mutual encouragement." A library is also in contemplation, the general plan being "to establish an institute of such repute that it will become the natural custodian of valuable collections of books and apparatus which are now so frequently scattered when their owners pass away."

In commending this scheme to the favourable attention of our readers we cannot abstain from noticing the eminently sound and practical character of the American Institute of Electrical Engineers. Casting a glance over the list of papers brought under its notice between May, 1884, and the corresponding month of the present year we are struck by the invariable utility of the subjects dealt with; and this impression is confirmed by such of the discussions as have been reported in American journals coming into our hands. But we have also been struck by the long-windedness of the speakers. It seems to

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be the custom of American electricians to invigorate their bodies during the session by frequent social gatherings, which take the form of dinners, and, if we may judge by what happened at the Philadelphia Electrical Exhibition, to obtain relaxation for the mind by indulging in infinite jest when the serious business is ended. These customs now recur to our memory in this relation, as explanatory of national traits which we had never been able to account for before. In one of the grotesquely humorous primers published at the fag-end of the Exhibition there occurred the following description of electric lights, which, it was said, were of two kinds, namely, "Our kind, and the other fellow's kind. Our light is much brighter than the other fellow's light. The other fellow's light is surrounded by a cloud of non-luminous verbosity." Now, irreverant and unseemly as this sort of caricature may appear, it is not wholly useless or impertinent. For simple verbosity our American fellow-workers—or, more correctly, speakers—incontestibly carry off the palm. When we take up an American technical paper we have always first to wade through or skip an exhausting oration. This we now very gladly attribute to the dinners. But for English verbosity of the "non-luminous" kind we have only one explanation to offer, namely, the absence of that humorous faculty which is ever alert in the native born American. On this side of the water we should be saved from many a non-luminous infliction if we were equally endowed with the sense of the ridiculous; and it is probably the Americans' superiority in this respect that has kept their Electrical Engineers strictly to the practical aspect of their profession, so soon as the preliminary orating has been got over. We have not obtained, and we hardly expect to receive from America any supremely valuable contributions to our stock of mathematical and scientific knowledge; but she has supplied us with much that is in the highest degree valuable in the domain of practical and applied science; and we are the more thankful for it, because its diffusion here may counteract our tendency to wander into fields of abstract speculation. The American Institute of Electrical Engineers has a very useful career before it; and the venture on which it is just now embarked deserves, and will receive, the best help we can give it.

CORRESPONDENCE.

"EDWARD DAVY."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of June 10th Mr. J. J. Fahie inquires if I am a debtor to E. Davy, with reference to my automatic accumulator switch. I beg to say that, never having seen a copy of the "History of Electric Telegraph," I never heard of E. Davy until this day. I hope Mr. Fahie will forgive my ignorance, which is due, no doubt, to my not having read his work.—Yours, &c., W. E. WILSON.

Daramona, Streete, Co. Westmeath, June 12th.

THE REGULATION OF SERIES TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Rankin Kennedy, in your last issue, says that the notices you have given of our work do not contain any actual practical results of careful tests to ascertain the losses in the induction coils. This is so; but we are at present, and have been for some time, engaged on these and similar tests, the results of which we shall shortly make public. But it would seem from Mr. Kennedy's letter that there really is no need of any such tests, for he goes on to say our figures are no doubt nearly correct. We may take it, therefore, that the error is not 100 per cent. But, Sir, we say that the loss in a coil is ·6 per cent., therefore Mr. Kennedy will admit the true loss is not double this, or 1·2 per cent.; and if he admits this, what need is there for elaborate experiments? Here, however, he falls into the most extraordinary error, for he says that the error is no doubt negligible when one coil is used, but if 1,000 coils were used the economy would be effected. Surely if the error is ·6 per cent. (an outside figure according to his showing) for one coil it is ·6 per cent. for a thousand. He might as well say that a large dynamo is less economic than a small one because more power is absorbed in the armature of the larger machine!

Mr. Kennedy also says that the core in all coils becomes hot. We have found that ours never get hot, and some never even warm.—Yours, &c., SHARP AND KENT.

Connaught Mansions, Victoria-street, S.W.

ARC LAMPS AT THE NEWCASTLE EXHIBITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Sayer writes in your issue of the 3d inst. as if the report that the "Diamond" arc lamps at the Newcastle Exhibition were unsteady because they could not be regulated prior to the opening night in consequence of the contractors being late for the work was a correct one. To let this pass would not be fair to Messrs. Woodhouse and Rawson. On account of the contract having been undertaken a long time after the other contracts were settled there was but little time left to manufacture and put the lamps up. These are run four in series, and grouped four in parallel with each other, and distributed over 31 acres of ground; consequently, as there was no time to run the lamps before the opening night, in several instances the lamps were coupled up wrongly, hence the unsteadiness. After the first night the connections were properly made, and only six lamps had to be at all adjusted, notwithstanding they were made in a great hurry and sent up to Newcastle in pieces. Since then the lamps have been absolutely steady.—Yours, &c., J. E. STEWART.

Industrial Exhibition, Newcastle on-Tyne,
June 9th, 1887.

ELECTRIC LIGHTING ON SALVAGE STEAMER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sure your readers will agree with me when I say that letters sent for insertion in *The Electrician* should at least lay claim to be fairly accurate, especially when written by those offering information on the subject of electric light installations.

The letter in your last issue signed "F. Hanson Perry" is in every particular so very far wide of the actual facts that I feel compelled to write this letter, and to ask you, with your usual impartiality, for its insertion.

The salvage steamer "Hyæna" was not fitted by either Messrs. Siemens and Co. or Perry and Company (Limited), but by the late firm of Perry and Cox, and the work having been done under my supervision and instructions in every detail from drawing up the tenders to lighting the first lamp, is my excuse for trespassing on your valuable space.

The dynamo is not a 4,200-watt machine, but a 6-unit (65 volts 92 amperes) compound; built by Messrs. Paterson and Cooper to run within 1,000 revolutions, it does its work effectually at 870. This machine is driven by a Gwynne invincible engine, and both engine and dynamo have worked admirably since being started last year. Instead of being 30 incandescent lamps there are only 10, no more being required.

The two Pilsen arc lamps take 28·26 amperes each, their resistance including the resistance in outer circuit to help them to feed being 2·3 ohms each. Your readers will see that 3,000 candle-power is below the usual estimate for such a current.

Regarding the specially designed switch-board (?) this is simply the ordinary one requisite for the installation, including the necessary cut-outs. As to the alleged difficulty of working arc and glow lamps in parallel, I will leave electricians to judge

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if there exist any. The burning of the arc lamps is simply perfect; but I regret to say the 100 candle-power diver's lamps have not proved the success anticipated, mainly owing to the frequent breakages of lamps and glasses.

In conclusion, I may say that this small installation has again proved the vast utility of the electric light on board ship.—Yours, &c., CHAS. W. COX.

50, Bedford-street, Liverpool.

THE ELECTRIC LIGHT FOR FISHING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having been with Mr. Perry during the fishing experiments he mentions, I think his statement calculated to mislead my fellow readers.

I should therefore like to say that the shoals of fish spoken of as swarming round the lamp resolved themselves into a solitary eel. No doubt fish, when near, would be attracted by a light, but exaggeration will do no good to the electric light or those interested in it.—Yours, &c.,

FREDERICK G. ROBINSON.

83, Spencer-street, Liverpool, June 13th, 1887.

THE LIGHTING OF THE GLASGOW TUNNELS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My letter to you of June 3rd seems somehow to have annoyed Mr. Carswell, of the North British Railway Company. If that company gave no preference to people who offered them valuable plans they are not singular in that respect, else there would have been some faint appearance of reason in Mr. Carswell's opinion, that the latter part of my letter had nothing to do with estimates; and if Mr. Carswell invented and patented one of my proposals, the fact illustrates another trade trouble, that as it is impossible to patent all the working methods which occur to those engaged in a new business like electrical engineering, the monopoly of each speciality becomes in the end the property of the man who first gets, or knows that he can get, an order for it.

The prices given in "A. and M.'s" letter to the railway company were only intended to give a general idea of the comparative cost of the various methods of lighting which they proposed, and I was quite prepared to have taken measurements and given exact prices and mechanical details if asked. I was not asked.

"A. and M.'s" letter to the company, however, seems to my mind to be fairly capable of conveying to the average practical mind that they proposed to supply current from a stationary engine and dynamo to the fitted trains as they passed through the tunnels. I suppose that Mr. Carswell had not at that time conceived his plan, or surely he would have at least suspected that they were on the same track, and would not have allowed some weeks—or was it days?—to elapse between receipt of "A. and M.'s" letter and his visit to his patent agent. The fact that accumulators were also named as an alternative method should have made it evident that they did not propose to use them in this method. The £800 was a rough guess at the cost of dynamos, conductors, contact rails, &c., for all the local tunnels, and I still doubt if these could be supplied and fitted in such a manner as to have little loss through leakage and none of that wavering of light which is at present complained of for very much less money. As to the £4 being sufficient for fitting carriages. The North British Railway Company, it seems, have had 64 carriages fitted by one man in a "gradual" manner in six months, or at the rate of about 2½ carriages of four to five compartments each per week. From the list of articles which "A. and M." do not make supplied by Mr. Carswell—some of which articles they do make, by the way—I infer that the company bought their material in a highly disconnected form, so that this "only one man employed in the work" must have made up the lanterns, the broken lamp shunts, fusible cut-outs, contact roller arms, &c., &c., and, indeed, I would not be the least astonished to learn that he had laid the permanent rail also, and made the switches, measuring instruments, and other appliances, which ought to be there if they are not, and which were not included in Mr. Carswell's list of material. Railway engineers are famous for enterprise; but I never can understand how it is that when they undertake a little electric lighting they are always able to pick up an idle workman or find some one among their linesmen who can do the work in a fourth of the time which would be required by workmen who are constantly engaged in such work, and who have all suitable appliances at hand. But suppose £1 per carriage was spent in wages and only one pair of contact rollers was used for a train and only one lamp for each compartment, as I would prefer to do, or perhaps one good lamp between two compartments, then the £4 would not be so very far out, although it would be easy to do the work more handsomely if the railway company could be persuaded to authorise the expense. But these details are of no public interest, and I will not trespass further on your space.—Yours, &c., J. M. M. MUNRO.

136, Bothwell-street, Glasgow.
June, 1887.

[This correspondence must now close.—ED. *E.*]

THE TELPHER LINE AT GLYNDE.

The telpher line at Glynde has now been in operation for a period of over two years, and the time has certainly arrived when the question as to the success or non-success of this system of transport should receive a final answer. The question is admittedly one of no slight importance. If telpherage can be demonstrated to be both technically and commercially practicable under the conditions of everyday service, it is not too much to assert that "the resources of civilisation" will have been appreciably widened, while the electrical industries will be materially benefited to an extent which no one can at present foresee.

But is the Glynde line a success? So little definite information having appeared in the public prints on the subject it is natural that remarks of an unfavourable character have not been altogether wanting. When, therefore, we received an invitation from the Telpherage Company to "come and see for yourselves what we are doing at Glynde," we did not hesitate—notwithstanding the torrid heat of the season—to undertake the expedition. Arriving at Glynde after two hours' stewing on the London, Brighton, and South Coast Railway, we found the genial engineer of the Telpherage Company (Mr. C. S. E. Crakanthorp), who accompanied us upon our tour of inspection. That the Telpher line is by no means in a state of inanition was soon apparent. Scarcely had we crossed the fence by the side of the railway when a gentle rumbling announced the approach of a telpher train. On it came at a perfectly uniform speed over the river, round by the bend at the end of the first field, and on to the loop which brings the skips over the railway trucks, into which their contents are tilted.* To one who has not seen it before, the first sight of a telpher train presents a very singular appearance. The peculiar cat-like way in which the skip in front climbs over the top of the poles and walks steadily over the inclines, while the wire rope sags beneath the weight of the train, is very striking. What is actually being done at Glynde may be summarised as follows:—Three trains are running continuously, each consisting of ten skips, and making on the average about 15 journeys daily. Each train carries rather over one ton of clay, so that the total weight moved is about 270 tons per week. The engine plant and the capacity of the line itself are equal to a service of four trains, so that 360 tons per week could be carried with very little increase on the present working cost. That cost is at present £6 per week, a figure which enables the Telpherage Company to carry out their contract with the Sussex Portland Cement Company, of Newhaven, under remunerative conditions, even at the low contract rate of 7½d. per ton.

We have incidentally alluded to the fact that the trains run

* This part of the line has been completely illustrated and described in previous volumes of this journal.

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upon wire ropes; it will probably be remembered that the original plans (or more strictly *one* of the original plans) of the inventors of the system (the late Prof. Jenkin and Profs. Ayrton and Perry) contemplated the use of steel rods stretching from span to span. Until experiment had actually been made upon a working scale it was confessedly difficult to determine which of these two methods would prove the better. On the one hand the employment of rods on the "cross-over parallel" system necessitated the use of spans all of the same length, or at least not exceeding a certain length, and there was also the difficulty of jointing and insulation. On the other hand, that system of connection did not readily lend itself to the employment of wire rope owing to the difficulty of securing it to the post-heads. It was therefore determined in the first instance to employ steel rods. The details of the construction of the line, together with the wonderfully ingenious devices for ensuring the safety and regularity of the service, were fully described by Prof. Perry in a lecture delivered at the London Institution, and reported in this journal in February, 1886.

The "cross over parallel" system, beautiful in conception as it is, has, however, one defect, which was pointed out by Prof. Perry in this lecture. Each time that the collecting wheels of the motor passed from one conductor to the other—that is to say at every post—the current through the motor is reversed, a reversal which necessarily entails sparking at the brushes. It remained to be seen how far this drawback would in practice counterbalance the advantages of the system in the matter of economy arising from the fact that only two (inter-crossed) conductors are required for both up and down lines.

After some experience, it became apparent that the motors at first adopted were unsuited to this particular class of work under the then existing conditions, and it unfortunately happened that the gentleman by whom the motors were originally designed was unable at the time to give his personal attention to the matter. We think it right to mention this fact because we are anxious not to give an unnecessarily unfavourable impression as to the merits of this particular motor, which, as Mr. Crakanthorp was himself careful to point out to us, has scarcely been able under the circumstances to receive a fair trial.

At this juncture, however, an Immisch motor was placed upon the line in parallel with one of the older type, and it at once became apparent that the former did the same work with exactly one half the energy supplied—that is, one half the number of amperes at the same volts. It is not, therefore, surprising that the Immisch motor has been finally adopted by the Telpherage Company. The type at present in use has a 4in. armature, weighs 105lb., and develops 1 horse-power running at 1,700 revolutions.

Concurrently with the change of motors it was decided to make such alterations to the line itself as would allow a simple parallel system to be adopted, principally in order that steel wire ropes might be substituted for rods, which were found to have a very much shorter life than had been anticipated. This has been carried out with great success; the steel ropes are $2\frac{5}{8}$in. in circumference, and are anchored to cross-beams buried in the soil, with tightening screws for straining up when required. The alteration necessitated, however, the employment of a second wire on both up and down lines in order to convey the current. This wire, which also takes the form of a steel wire rope of $1\frac{1}{2}$in. circumference, is insulated throughout its length. The current is taken off by a jockey pulley made in copper with wide flanges, and the wire upon which the train runs is earthed throughout, as also is the negative terminal of the dynamo. The system, in fact, has now reverted very nearly to that described in one of the earlier patents of Profs. Ayrton and Perry.

The conditions under which a motor running upon a telpher line is worked are necessarily such as to submit the apparatus to an extremely severe test. The protection which can be given against the weather is very slender at the best.

It is under such conditions that the Immisch motors at Glynde are now working with complete success. This satisfactory result has not, however, been attained without a good deal of painstaking attention to matters of detail both on the part of the Immisch Company and of Mr. Crakanthorp. The Immisch Company at one time sent one of their representatives (Mr. A. Snell) to stay for some time upon the spot in order to study the working conditions as completely as possible. The results now attained will be appreciated from the statement that the motors frequently run for a fortnight without even having their brushes readjusted. The commutators receive a touch of vaseline from the switch man at the end of every journey.

The average E.M.F. along the whole line is 170 volts, there being only a volt or two difference between the engine house and the extremities of the line. The total current taken by the three trains amounts to 20 amperes; but owing to the admirable action of the automatic circuit-closers governing the speed of the trains (a feature which is due to the late Prof. Fleeming Jenkin) it is comparatively seldom that the full current is taken for more than a very short interval. The variations of current between 8, 14, and 20 amperes, as shown in the engine-room ammeter, follow one another in rapid succession. The loss by leakage is two amperes. The governors, it will perhaps be remembered, act by centrifugal force, entirely cutting off the current when the speed of the armature exceeds a certain point. The break is made first on carbon and afterwards on copper contacts. Although the gradients on the line are very slight, the trains sometimes run over 100 yards without taking current. The speed of the trains, as judged by the eye, is remarkably uniform, a velocity of about 4 miles per hour being maintained throughout the whole line, both by empty and by full loads. The trains are started at either end, through a set of resistances, which are cut out in four sections, so that the start is effected with great smoothness.

In the engine house the Ruston and Proctor semi-portable engine and the Crompton compound-wound dynamo both look good for many years to come, although, owing to the continuous variations of the load (through the action of the motor governors), it may be assumed that the work is of a somewhat trying character.

We will only add, in conclusion, that the result of our visit has been to impress forcibly upon our minds the fact that, upon the technical side, telpherage must no longer be looked upon as a scientific toy, but has become a thoroughly practical and efficient system of transport, combining the qualifications of cheapness, simplicity, and certainty—a system which, while not intended to compete with steam for heavy traffic, is yet capable of affording a complete solution of an important class of problems in the industrial development of old countries as well as of new colonies and of semi-civilised lands. We do not, however, anticipate, nor is it on the whole desirable, to see "a boom" in telpherage; but that, under capable management, the business of the Telpherage Company will steadily grow into industrial importance we regard as a certainty.

LE MANS.—The gas light company at Le Mans are preparing to supply electric light from a central station.

THE EQUIVALENT OF ZINC.—At a recent meeting of the Chemical Society a note was read by Lieut.-Colonel Reynolds, late R.E., and Prof. W. Ramsey on the equivalent of zinc. The determination has been made by measuring the hydrogen evolved on dissolving zinc in acid, every precaution being taken to ensure accuracy; the weight of the hydrogen obtained was deduced from Regnault's determination of the density of hydrogen. The zinc used was separated by electrolysis from zinc sulphate purified to the utmost possible extent. The last sample prepared was so nearly pure that dilute acid would scarcely act on it. In all 29 experiments were made. Four experiments had to be rejected; nine were not fully corrected, and therefore were also rejected; the next 11 were considered preliminary, the mean atomic weight deduced from them being 65·2430; finally, five experiments were completed, and the results—free from all known sources of error—obtained as the mean yielded the figure $65{\cdot}4787 + 0{\cdot}016135$.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XLI.

BY OLIVER HEAVISIDE.

Nomenclature Scheme. Simple Properties of the Ideally Perfect Telegraph Circuit.

To explain the word "permittance" that I used in the last Section, I may remark that in stating my views in 1885 in several communications to this journal on the subject of a systematic and convenient electrical nomenclature based upon the explicit recognition of the three fluxes, conduction current, magnetic induction, and electric displacement, proposing several new words, some of which have found partial acceptance, I remarked upon the unadaptable character of the word "capacity." It must be the capacity of something or other, as of permitting displacement. I did not then go further in connection with the flux displacement than to use "elastance," for the reciprocal of electrostatic capacity. The following shows the scheme so far as it is at present developed :—

Flux.	Force/Flux.	Flux/Force.	Force.
Conduction Current	Resistance. / Resistivity.	Conductance. / Conductivity	Electric.
Induction	? / ?	Inductance. / Inductivity.	Magnetic.
Displacement	Elastance. / Elastivity.	Permittance. / Permittivity.	Electric.

Why elastivity? Maxwell called the reciprocal of the permittance of a unit cube "the electric elasticity." By making it simply elastivity, we first get rid of the qualifying adjective; next, we avoid confusion with any other sort of elasticity; and, thirdly, we produce harmony with the rest of the scheme. There are now only two gaps. "Resistance to lines of force," or "magnetic resistance," now used, will not do for permanent employment. Besides the above, there is impedance, to express the ratio force/flux in the very important case of sinusoidal current. Impedance is at present known by various names that seem to be founded upon entirely false ideas. The impedance (which, derived from impede, need not be mispronounced) of a coil is the ratio of the amplitude of the impressed force to that of the current. A coil used for impeding may be called an impeder. The same definition obviously applies in any case that admits of reduction to *one circuit* (even though parts of it may be multiple), *e.g.*, any number of coils in sequence, in sequence with any number in parallel (to be regarded as one), in sequence with a condenser, or arrangement reducible to a condenser. The impedance is always reducible to $(R^2+L^2n^2)^{\frac{1}{2}}$, where R is the effective *resistance*, which is real, and L the effective inductance, or sometimes *quasi*-inductance. It is not necessary to exclude inductive action on *other* circuits, although the heat corresponding to R may be partly in them. As for resistance, it is very desirable to confine its use to the established meaning in connection with Joule's law.

Now let R, L, S and K be the resistance, inductance, permittance and leakage conductance per unit length of a circuit; and let V and C be the potential difference (an awkward term) and current at distance x. We have the following fundamental equations of connection :—

$$-\frac{dV}{dx}=(R+Lp)C, \qquad -\frac{dC}{dx}=(K+Sp)V, \quad . \quad (1d)$$

p standing for d/dt. Observe that the space-variation of C is related to V in the same manner (formally) as the space variation of V is related to C, so that we can translate solutions in an obvious manner by exchanging V and C, R and K, L and S, which are reciprocally related, in a manner.

To fix ideas, the circuit may be the common pair of parallel wires. There is one case in which the four constants are all finite that is characterised by such extreme simplicity that it is desirable to begin with it, especially as it casts a flood of light upon all the other cases, which may be simpler in appearance, and yet are immensely more complex in results. Let

$$R/L=K/S=s, \quad \text{and} \quad LSv^2=1 \quad . \quad . \quad . \quad . \quad . \quad (2d)$$

The number of circuit constants is now virtually three, owing to the fixing of the fourth constant. The equation of V is now

$$v^2\frac{d^2V}{dx^2}=(s+p)^2V \quad . \quad . \quad . \quad . \quad . \quad (3d)$$

or, which is equivalent,

$$v^2\frac{d^2u}{dx^2}=p^2u, \quad . \quad . \quad . \quad . \quad . \quad . \quad (4d)$$

if $V=ue^{-st}$. Since (4d) is the equation of undissipated waves, with constant speed v, whose solution consists of two oppositely travelling arbitary waves, the complete solution of (3d) consists of such waves attenuated as they progress at the rate s (logarithmic). Thus,

$$V=f(x-vt)e^{-st} \quad . \quad . \quad . \quad . \quad . \quad (5d)$$

is the complete expression of the positive wave, if $f(x)$ be the state when $t=0$. Shift the wave bodily a distance vt to the right, and attenuate it from 1 to e^{-st}, and we obtain the state at time t. The corresponding current is

$$C=V/Lv=SvV. \quad . \quad . \quad . \quad . \quad . \quad (6d)$$

in every part of the wave. To express a negative wave, change the sign of v in (5d) and (6d). The second form of (6d) says that a charge Q moving at speed v is equivalent to a current Qv.

Since V is an E.M.F., it is convenient to reckon Lv in ohms, as was done before; v is 30 ohms, in air, when it has its greatest value (speed of light, 30 earth quadrants per second) and L is a convenient numeric. L = 20 is a common value (copper suspended wires); in this case our "resistance" is 600 ohms. But it is not "ohmic" or "joulic" resistance; the current and E.M.F. are perpendicular. V is the line-integral of the electric force across the dielectric from wire to wire, and C is the line-integral ($\div 4\pi$) of the magnetic force round either wire. The electric and magnetic forces are perpendicular, and so are V and C regarded as vectors. The product VC is the energy current; their ratio is the important quantity Lv.

In a positive wave V and C are similarly signed, and in a negative wave are oppositely signed. Thus, if the electrification be positive, the direction of the current is the direction of motion of the wave; whilst if it be negative, the current is against the motion of the wave.

When oppositely travelling waves meet, the resultant V is the sum of the two V's, and the resultant C the sum of the two C's.

Thus, if the waves be so shaped as to fit, then, on coincidence, V is doubled and C is annulled. The energy is then all electric. But if the electrifications be opposite, V is annulled and C is doubled, on coincidence. The energy is then all magnetic. On emergence, however, the two waves are unaltered, save in the attenuation that is always going on.

The electric energy is $\frac{1}{2}SV^2$ per unit length of circuit, and the magnetic energy is $\frac{1}{2}LC^2$. From this, by (6d) and the second of (2d) we see that the electric and magnetic energies are equal in a solitary wave, either positive or negative. The dissipativity in the wires is RC^2 and outside them KV^2 per unit length of circuit. These are also equal, for the same reason.

Should the disturbance be given arbitrary, *i.e.*, V and C any function of x, the division into the positive wave V_1 and the negative wave V_2 is effected thus :—

$$V_1=\tfrac{1}{2}(V+LvC), \qquad V_2=\tfrac{1}{2}(V-LvC). \quad . \quad (7d)$$

Notice that $SV_1V_2=-LC_1C_2$, so that the total energy per unit length is always

$$S(V_1^2+V_2^2)=L(C_1^2+C_2^2). \quad . \quad . \quad . \quad (8d)$$

Similarly, the total dissipativity is always

$$R(C_1^2+C_2^2)=K(V_1^2+V_2^2) \quad . \quad . \quad . \quad (9d)$$

Similarly, the total energy current is always

$$V_1C_1+V_2C_2, \quad . \quad . \quad . \quad . \quad . \quad (10d)$$

since $V_1C_2=-V_2C_1$.

If at a given moment $V=V_0$ through unit distance anywhere, with no C, this immediately breaks into two equally big waves, one positive, the other negative, which at once separate. If initially there be no V, but only C, the same is true for the

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COMPARATIVE TABLE SHOWING THE PERFORMANCES OF CERTAIN DYNAMOS.

The following table is reprinted from the *Electrician and Electrical Engineer* of New York for June, 1887, and has been compiled by Mr. D. C. Jackson. This table has been enlarged and corrected since its first appearance in April last, as in its earlier form several errors appeared, some of which were pointed out by our correspondents.

Column I. gives volts generated per foot of armature wire.
" II. " " " " " and per unit of peripheral velocity.
" III. gives volts per foot of wire and per one revolution per minute.

Type of Armature.	Machine.	Revs. per min.	Velocity.	I.	II.	III.	E.M.F.	Current.	Authority.
Siemens	Edison-Hopkinson	800	2100	·45	·013	·00060	110	300	Kapp and Crompton.
"	Edison	1750	2850	·312	·0065	·00018	125	40	.....
"	Weston	1000	1850	·234	·0077	·00024	150	20	Prof. Anthony.
"	Mather	2750	3200	·520	·0098	·00020	125	40	.....
"	Wenström	460	2225	·229	.0062	·00050	110	190	*La Lumière Electrique.*
"	2½ inch Siemens	3000	1875	·182	·0060	·00006	70	...	Prof. Anthony.
Gramme	Manchester (Mather and Platt)	1050	3300	·402	·0075	·00038	110	220	Kapp and Crompton.
"	Crompton	400	1620	·230	·0085	·00057	600	120	*Electrician*, London.
"	" (Plating)	700	2840	·336	·0070	·00048	110	490	"
"	Crompton	...	...	...	·0095	...	110	217	Crompton.
"	"	...	...	...	·0070	...	110	100	"
"	"	...	...	...	·0055	...	60	33	"
"	Elwell-Parker	...	...	...	·0080	...	110	460	"
"	" (4 pole)	...	...	...	·0065	...	...	...	Kapp.
"	" (2 pole)	...	...	...	·0045	...	...	...	"
"	Kapp	...	...	...	·0070	...	110	125	Kapp and Crompton.
"	Goolden-Trotter	800	3000	·378	·0075	·00047	130	200	Ravenshaw.
"	" "	765	2140	·264	·0074	·00034	56	285	"
"	" "	950	2850	·289	·0051	·00030	60	200	"
"	Sperry (Internal pole pieces)	750	3150	·226	·0043	·00030	850	23	.....
"	Old Gramme	1030	2875	·109	·0023	·00011	200	25	Prof. Anthony.
"	Raffard-Breguet	1400	2950	·115	·0022	·00008	110	35	Crompton.
"	Ball ("Unipolar")	1380	3800	·132	·0016	·00010	470	8	*Electrician and Electrical Engineer*, N. Y.
"	"	1180	...	·113	...	·00010	710	8·2	"
"	Deprez (Paris Creil)	216	1475	·081	·0033	·00037	3000	9·9	Levy and Kapp.
Pacinotti	Phœnix	...	...	·290	·0058	·0006	110	380	Kapp and Crompton.
Brush	Brush	850	4670	·200	·0026	·00024	3000	9·5	.....
Thomson-Houston	Arc	...	...	...	·0019	...	2000?	10?	Kapp.
"	"	900	3770	·111	·0018	·00012	700	10	.....
"	Incandescent	1250	4335	·364	·0051	·00029	80	200	.....
Gramme	Van Depoele (60 h.p. transmission of power.)	800	4300	·238	·0020	·00017	550	60	.....

current waves; *i.e.*, the result is two equal but oppositely signed V waves, which at once separate.

What happens when disturbances reach the end of the circuit depends upon the nature of the terminal connections there. At present only one case—the simplest—will be noticed. Let there be a resistance of amount Lv at the distant end B of the circuit. The terminal condition is then $V = LvC$. But this is the property of a positive wave. Hence all waves travelling towards B are immediately *absorbed* on reaching B. The electricity is all gobbled up at once, so to speak. Similarly, if there be a resistance Lv at the end A (where $x = 0$) it imposes the condition $V = -LvC$, which is the property of a negative wave, so that all disturbances on arrival at A are absorbed immediately. Thus, given the circuit in any state of electrification and current, without impressed force, it is wholly cleared in the time l/v at the most, l being the length of the circuit.

Now, let the circuit be short-circuited at A, and have a resistance Lv at B. Insert an impressed force e at A momentarily, producing $V = e$ through unit distance, say. This will travel towards B at speed v, attenuating as it goes, and on arrival at B what is left will be at once absorbed. This being true for every momentary impressed force, we see that if it be put on at time $t = 0$, and kept steadily on thereafter, the full solution is

$$V = e.\epsilon^{Rx/Lv} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11d)$$

from $x = 0$ to $x = vt$, and zero beyond. Thus the steady state at a given point is instantly assumed the moment the wave front reaches it. After that, there is still transfer of energy going on there, viz., to supply the waste in the part of the wave that has passed the spot under consideration, and to increase the energy at the front of the wave. The current is V/Lv, as before. On reaching B, the current is

$$C = \frac{e}{Lv}\epsilon^{-Rl/Lv} = \frac{e}{Rl} \times \frac{Rl}{Lv}\epsilon^{-Rl/Lv} \quad . \quad . \quad . \quad (12d)$$

If we let Rl the resistance of the circuit be 3,000 ohms, which is 5 times the before assumed value of Lv, then the received current is

$$C = \frac{e}{150Lv} = \frac{e}{90{,}000} = \frac{e}{30Rl} \quad . \quad . \quad (13d)$$

The attenuation is such that the current is one-thirtieth part of the full steady current with perfect insulation.

The electrostatic time-constant of the circuit is

$$RSl^2 = \frac{l}{v} \times \frac{Rl}{Lv} \quad . \quad . \quad . \quad . \quad (14d)$$

or, in our example, five times the time of a journey from A to B. It may have any value we please. If we want it to be ·1 second, l/v must be ·02 second, and therefore $l = 6{,}000$ kilometres, which requires $R = ·5$ ohm per kilom. This is lower than that of any telephone line yet erected. But to make the electrostatic time-constant ·05 second, with the same attenuation, it must be 3,000 kilom. at 1 ohm per kilom.

If e vary in any manner at A, the current at B is given by (12d), in which e varies in the same way at a time l/v later. As there is no distortion it becomes a question of suitable instruments. With proper instruments no doubt the permissible attenuation could be much greater, and the circuit much longer. Again, if we raise the insulation we lessen the attenuation. We bring on distortion, but a good deal is allowable, so that again we can work further. The insulation resistance should be ·36 megohm per kilom. in the 3,000 kilom. example; the product of the resistance of any portion of the circuit (wires) into the insulation resistance of the corresponding part is $(Lv)^2$. In the 6,000 kilom. example it should be ·72 megohm per kilom. But if it be not arbitrary waves, but only waves of high frequency that are in question then we may approximate to the nondistortional transmission without attending to the exactly required leakage.

(To be continued.)

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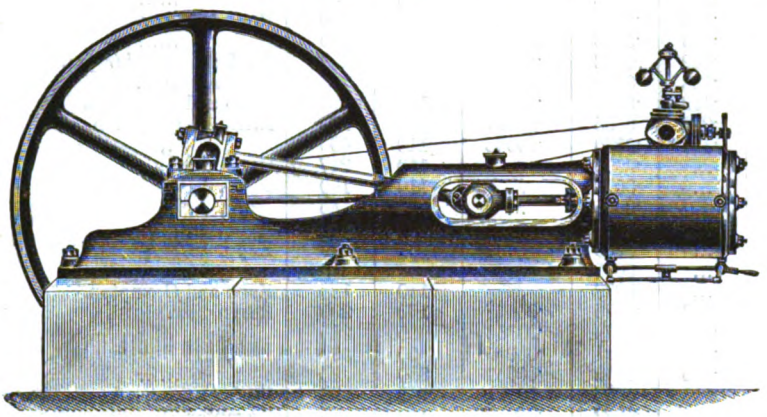
QUICK-SPEED STEAM ENGINE BY RANSOMES, SIMS, AND JEFFERIES.

The accompanying figure represents a new design of Messrs. Ransomes, Sims and Jefferies for a quick-speed engine specially suited for electric lighting work. The makers supply the following details of the design :—In this engine the bed plate, cross head guides and plummer blocks for crank-shaft are all cast in one piece, the cylinder, with its valve chest, being bolted to the end of the engine frame. This design is very strong, neat and compact. The foundation plate is planed on the underneath side for facility of fixing. The fly-wheel is of ample width for giving off the full power



Ransomes, Sims, and Jefferies' Quick-Speed Engine.

of the engine. A force pump, with brass valves and seatings, worked by an excentric from crankshaft, is supplied when desired.

THE NEWTON PRIMARY BATTERY.

The advantages of electric lighting by means of the primary battery are so numerous and so obvious that it is scarcely to be wondered at if, in spite of the long record of past failures, determined and persevering attempts are still being made to overcome the difficulties which have hitherto proved an insuperable barrier to any extensive employment of the method. It is a little unfortunate that these difficulties are chiefly of a character which do not impress themselves forcibly upon the inexperienced and non-technical mind. Results of an apparently economical and satisfactory kind are very readily obtained with many different cells so long as the scale of working is confined within narrow limits ; but the margin of commercial profit only too often diminishes to the vanishing point as soon as the problem is fairly faced upon an extended scale of working.

If we are somewhat unhopeful in the tone of these remarks, it is not because we think that the Newton cell stands any worse chance of success than certain others which we could name, whose failure has resulted as much, or more, from lack of business capacity in the management as from any inherent defects in the system. We take it that a primary battery which is capable of doing service at a fairly economical rate, and also (this is of the first importance) without entailing annoyance or inconvenience upon the user, has a distinct field open to it, in which an extensive business might in time be done, notwithstanding the fact that the cost of electric lighting by this means does not admit of comparison on equal terms with gas. On this point we have often stated our firm conviction, which we have never yet found occasion to alter, and which is shared by all who are really qualified to form an opinion, that a battery consuming zinc as fuel is not able, and until the cost of zinc is vastly lower never will be able, to compete with gas on anything like equal terms.

But, while maintaining this opinion unchanged, we have to recognise the existence of a type of cell—Mr. Newton's among the number—for which the claim is made that, although zinc is consumed in the cell, yet it is recovered in a saleable form—as oxide or as sulphide. The formation of bye-products, which shall cover or materially reduce the cost of working a battery has always, and naturally, had a fascination for electro-chemists, and numberless efforts have been made to solve the problem in a commercial sense. If these efforts have hitherto been without success, it does not by any means follow, nor should we be disposed to predict, that all future attempts of a similar character will remain equally barren of result.

We have already hinted that in the Newton cell the zinc is recovered in a saleable form, but we are unable to express an opinion as to the value of the process, inasmuch as the patents not having been completed at the time of our inspection of the cell, it was reasonably preferred not to disclose the secret. Our readers will, however, easily be able to understand the general drift of the method of the working which is to be adopted, if we state that the Newton is a single-fluid cell, and, like the Lalande, consists of a plate of zinc in a solution of caustic potash ; the negative plate, which may be either iron or copper, being surrounded by a layer of peroxide of lead packed in a parchment bag of narrow width. The peroxide acts, of course, as a depolariser ; oxide of zinc is formed and is dissolved in the caustic potash. The purely electrical properties of the cell were reported on some time ago by Dr. Walmlsey. The following is an extract from his report :—

"Three of the above cells were joined up in series and discharged through a small resistance with the intention of testing them under a current of rather more than three amperes. The E.M.F. on open circuit immediately after pouring in the liquid was 0·75 volt per cell ; but some preliminary tests extending over a few hours having been made in order to gain some idea of the possible behaviour of the cells, the E.M.F. on starting the above-named current was only 0·69 volt per cell. An abstract of the results is given in Table A.

"During the whole of these experiments the external resistance was not altered. The rise of the current during the earlier part of the test is due to the decrease in the internal resistance, and its more rapid fall in comparison with the fall of E.M.F. was due to an increase of internal resistance. These phenomena were observed in the previous cells. The actual internal resistance was 0·87 ohm per cell at starting in the preliminary tests, 0·133 ohm at the 103rd hour, and much higher when the circuit was broken. The above results speak for themselves.

"The fourth cell was tested for the effect of local action. It was short-circuited through a few inches of No. 18 copper wire for 9½ hours. The zinc plate was then carefully weighed and replaced in the cell. At the end of eight days it was again weighed, and was found to have lost only 3·80 grammes, showing that the local action is practically negligible. No tests were made of the composition or probable value of the bye-products or of other points that are important from a commercial point of view for lighting purposes, my instructions being to report only on the electrical behaviour. My tests show that currents of the order required for the above purposes may be taken from the cells for many successive hours."

TABLE A.

Time in hours from commencement of experiment.	Current in amperes.	Average electromotive force per cell in volts.
0	3·45	0·69
11	3·45	—
33	3·57	0 69
50	3·45	—
60	3·30	—
84	3·30	0·68
111	3·17	—
122·5	3·13	0·63
130	2·98	0·61
155	2·27	—
165	1·99	0·59

From this report it will appear that although the E.M.F. is very low, yet the cell possesses undoubted merit. While, however, we have pleasure in recognising this, and are anxious that the battery should have fair play, we feel it all the more strongly to be our duty to appeal to the syndicate in its own interests to take warning by the fate of similar ventures, some of them quite as promising at first sight, which have been wrecked by injudicious (we might use a much stronger term) and extravagant predictions.

Our appeal is not by any means superfluous in this case, as a glance at the printed statements made by the New Electric Light Syndicate will show. The first line reads "Electricity as cheap as gas," and, to make only one other quotation, we read "A brilliant and steady light is maintained for 120 hours without attention. Most other batteries last only a few hours." This kind of thing is certainly a tactical mistake, and we take it to be the truest kindness to say so. The appearance of the Newton cell is *not* an era-marking event, even though it should prove, as we hope it may, a serviceable type of battery.

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THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION, AND CAPACITY.*

BY W. E SUMPNER, B.SC.

It has long been known in a general way that the effects of self-induction and capacity are opposite in kind. Self-induction in a relay produces sparking, but if a condenser be shunted to the relay sparking is prevented. Condensers are used in induction coils to prevent sparking and to hasten change of magnetisation. Mr. Preece told us while discussing Prof. Hughes's paper that a resistance shunted by a condenser is placed in a telegraph circuit to overcome the effects of self-induction. Prof. Silvanus Thompson told us (*Journal*, May 13th, 1886) that Mr. Black, in 1878, "showed that one difficulty in long-distance telephoning could be effectually got over by putting a condenser in the circuit as a bridge to any electro-magnet in the line." The reason of this is possibly that the condenser diminishes the effective self-induction of the line. Mr. Blakesley remarked on the same occasion that the working of a telephone circuit completed through a condenser could be improved by adding self-induction to the circuit up to a certain amount. After that maximum had been reached, an increase of the self-induction of the circuit or a diminution of its capacity would be a disadvantage. Now possibly the reason of this is to be found in the fact that capacity is like a negative self-induction. Capacity in a circuit helps change of current. Self-induction in a circuit hinders change of current. Just as self-induction in a telephone circuit retards some of the waves of current more than others, and thereby renders impure the sounds given out, so capacity in a telephone circuit accelerates some of the waves more than others, and produces a similar result. The ideal telephone circuit should have no effective self-induction. What the resistance of it is does not matter so much. When Mr. Blakesley added self-induction to his telephone circuit, the improvement he noticed in the working was probably not because the mere addition of self-induction was an improvement, but because the effect of the capacity was diminished more and more as self-induction was added, until a point was reached when the effect of the latter counterbalanced that of the former. It was then that the line worked at its best. It was then that the waves of current travelled along the line without changing much in form.

In working with the secohmmeter it is possible to make the resistance of the coil having self-induction appear either to increase or to decrease, according to the way in which the commutator is turned. It is even possible by turning the secohmmeter at a particular speed to reduce the apparent resistance of the coil to zero. The reason is that self-induction when currents are increasing acts like an increase of resistance, and when currents are diminishing like a diminution of resistance. Exactly the reverse holds good of capacity. In the armature of a dynamo self-induction acts like an increase of resistance because the current has to be started in each coil as it passes the commutator. If it were practicable to shunt each coil of the armature by a condenser, the effect of capacity would be that of a diminution of resistance each time the coil passed the commutator. Just as the resistance of an armature is effectively increased by its self-induction, and increased by an amount proportional to its speed, so the result of capacity would be to diminish the effective resistance by an amount proportional to the speed. If, therefore, it were practicable to use condensers of suitable capacity, it would be possible not only to get rid of the effect of self-induction, but actually for a particular speed to diminish the effective resistance of the armature to zero.

It is important to consider whether the opposite natures of self-induction and capacity can be utilised practically in diminishing the self-induction of transformer circuits.

In the appendix of the paper of Profs. Ayrton and Perry will be found two or three methods which I devised for measuring self induction. In each of those methods a condenser, shunted to the coil, was used to prevent sparking at the intervals between the reversals; and although the condenser was afterwards dispensed with because a short circuit was allowed to occur, yet the formula was first worked out in each case on the supposition that the condenser was used. The result came out in every instance just as if the condenser had been absent, and as if the self-induction of the coil had been diminished by the product of the capacity of the condenser and the square of the resistance of the coil shunted to the condenser.

Now, this not only showed that each of the methods for measuring self-induction was also a method for measuring capacity, but it seemed to indicate that there was some law regulating the external action of a condenser shunted by a wire.

The law was easily found to be as follows:—In any network of conductors, if one of the branches be composed of a condenser whose terminals are shunted by a wire, with or without self-induction, and if the currents in the network vary from any cause from one steady set of values to another, the extra quantity of electricity which will pass through a galvanometer placed in any arm of the network, in consequence of the capacity, will be exactly as if the condenser were altogether removed and the self-induction of the wire were diminished by the product of the capacity of the condenser and the square of the resistance of the wire shunting it.

Let E be the electromotive force, constant or variable, applied to the terminals of a condenser through a resistance R; let K be the capacity of the condenser, r the resistance, and L the coefficient of self-induction of the wire shunting the condenser; let x be the current through the wire r, and y the current through the condenser, and let V be the potential difference of the condenser terminals at any moment; then

$$E - V = R\,(x+y),\quad V = r\,x + L\frac{dx}{dt},\quad y = K\frac{dV}{dt};$$

whence $$E = (R+r)(x+y) + (L - K r^2)\frac{dx}{dt} - K L r \frac{d^2x}{dt^2}.$$

The extra current due to K and L will be that caused by the extra electromotive force

$$(L - K r^2)\frac{dx}{dt} - K L r \frac{d^2x}{dt^2},$$

and the total quantity of electricity passing through a galvanometer placed in any other branch of the network will be proportional to the integral of this extra electromotive force. If the currents in the network vary from one steady state to another, the integral is

$$(L - K r^2)(x_1 - x_2),$$

where x_1 and x_2 are the two steady currents through the wire. Now, as these are not affected by K, the effect on the galvanometer is exactly as if the condenser were removed and the self-induction of the wire were diminished to

$$L - K r^2.$$

The effect of the capacity is that of a negative self-induction. It may be said to be due to this cause that it is possible to compare self-induction with capacity in the way described by Clerk-Maxwell.

It seems very strange that Clerk-Maxwell, who devised a method for measuring self-induction absolutely, and who also gave methods for comparing self-induction, mutual induction, and capacity, failed to observe that his absolute method was equally applicable to the measurement of all these quantities. If a galvanometer be placed in one of the branches of any network of conductors, such as the Wheatstone bridge, the effect on the galvanometer due to different electromotive forces acting in different branches of the network is well known to be the sum of the effects produced by each electromotive force acting separately. Now the effect of self-induction in a wire through which a varying current is passing is to generate an electromotive force in the wire proportional to the rate at which the current varies. Mutual induction and capacity produce similar effects. So that, while currents are being established in a Wheatstone bridge in and between the branches of which exist induction and capacity, the extra current through the galvanometer will be that caused by the extra electromotive forces in the network, and will be the sum of the extra currents produced by each of these electromotive forces taken separately. The total quantity of electricity going through the galvanometer in consequence of the induction and capacity will be a simple linear function of the coefficients of those quantities.

Indeed, Maxwell has shown that if self-induction exists in one of the arms of a Wheatstone bridge which is balanced for steady currents, the fling of the galvanometer when the galvanometer circuit is closed before the battery circuit, is directly proportional to the self-induction. He has, moreover, shown that it is possible to balance the bridge for both steady and variable currents, provided a certain relation holds between the resistances of the arms and the coefficients of induction or capacity that are being compared. If, for example, as in Fig 5, we are comparing self-induction with the capacity, suppose L is the self-induction of the branch r, and K is the capacity shunted to the branch q, then if $p\,s = q\,r$ and $K\,q\,r = L$, Clerk Maxwell has shown that the bridge will be balanced for both steady and variable currents. Now this shows that the effect of K is equal and opposite to that of L; and since the swing of the galvanometer when K is removed is proportional to L, it follows that the swing of the galvanometer when L is removed is proportional to K. The same remark applies to mutual induction. It at once follows that Clerk-Maxwell's method of determining self-induction in absolute measure is also a method of determining mutual induction and capacity in absolute measure. We have merely to proceed in exactly the same way as when determining self-induction, and to divide the result we obtain by a simple ratio or a simple product of the resistances in the arms of the bridge.

Perhaps Clerk-Maxwell missed seeing this because he foresaw the existence of null methods and did not consider the meaning of the galvanometer swing when the bridge, although balanced for steady currents, was not balanced for variable currents. However this may have been, the null methods of Clerk-Maxwell form an example of how very tedious and difficult to work null methods may sometimes become. It is not only necessary to have a very delicate galvanometer and an extremely delicate adjustment of the bridge, but only one particular adjustment of the bridge will give any result at all, and for this reason these double null methods are quite unsuited to those to whom time is any object.

Once, however, the fact is grasped that the swing of the galvanometer in a bridge balanced for steady currents is a linear function of the inductions and capacities in the bridge, it is easy to see a much more rapid way of comparing the coefficients than by the methods of Clerk-Maxwell.

Let L_x be the self-induction of the branch x; let K_x be the capacity of the condenser shunted to the branch x; let M_{xy} be the mutual induction of the branches x and y.

If we are comparing L with M, as in Fig. 6, we have

$$L_s + \frac{p+r}{p} M_{sb} = k D_1,$$

where p and r are the resistances of the branches as indicated in the figure, D_1 is the first swing of the galvanometer when the bridge being balanced for steady currents has an electromotive force suddenly put in the battery circuit, and where k is some constant.

Now reverse the connections of either of the coils possessing mutual induction. The bridge is not altered except that the sign of M_{sb} is

* Paper read before the Society of Telegraph-Engineers and Electricians, on May 12th.

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charged. If we now take another swing, we get

$$L_s - \frac{p+r}{p} M_{sb} = k D_2 ;$$

whence

$$L_s : M_{sb} = \frac{p+r}{p} \frac{D_1 + D_2}{D_1 - D_2}.$$

If we are comparing two self-inductions, as in Fig. 1, we get in the same way, after balancing the bridge,

$$p L_s - r L_q = k D_1.$$

Now remove the branch q and substitute resistances till the bridge is again balanced. We then have

$$p L_s = k D_2 ;$$

whence

$$\frac{L_s}{L_q} = \frac{r}{p} \frac{D_2}{D_2 - D_1}.$$

If we are comparing two capacities, as in Fig. 3, which represents a generalised form of De Sauty's method, we have in the same way (if the bridge is balanced for steady currents)

$$s K_s - q K_q = k D_1 ;$$

by removing the connections of the condenser q we have

$$s K_s = k D_2,$$

or

$$\frac{K_q}{K_s} = \frac{s}{q} \frac{D_2 - D_1}{D_2} = \frac{r}{p} \frac{D_2 - D_1}{D_2}.$$

This must hold when the resistances s and q are infinite—*i.e.*, in De Sauty's method. In this case, however, as well as in the case represented in Fig. 2, the swing method is needless, as a single null method is applicable.

If we are comparing capacity with mutual induction, as in Fig. 4, we get in the same way

$$\frac{q+s}{q} M_{rb} - q r K_q = k D_1 ;$$

and by disconnecting the condenser we get

$$\frac{q+s}{q} M_{rb} = k D_2,$$

or

$$M_{rb} : K_q = \frac{q^2 r}{q+s} \frac{D_2}{D_2 - D_1}.$$

If we are comparing self-induction and capacity, as in Fig. 5, we get

$$L_r - q r K_q = k D_1 ;$$

and by removing the condenser,

$$L_r = k D_2,$$

$$L_r = \frac{D_2}{D_2 - D_1} q r K_q .$$

q r must generally be large, and it is better to make q larger than r.

The following table gives the results of a set of experiments made on an induction coil the ratio between whose coefficients of self and mutual induction was required. The ratio $r : p$ of the arms of the bridge was varied from 50 to 200, the ratio of the coefficients being about midway between these numbers.

MUTUAL INDUCTION AND SELF-INDUCTION.

Ratio of arms r/p.	Induction measurement.	Mean swing.	Sum of swings.	Ratio, L·M.	Error from mean.
57·10	L+58·1M	565	774	126·3	0·9
	L−58·1M	209			
71·77	L+72·8M	601	765	127·4	0·2
	L−72·8M	164			
82·15	L+83·1M	595	720	127·4	0·2
	L−83·1M	125			
100·77	L+101·8M	594	659	126·8	0·4
	L−101·8M	·65			
127·07	L+128·1M	545	542	126·7	0·5
	L−128·1M	−3			
206·99	L+208M	531	406	128·5	1·3
	L−208M	−125			
			Mean = 127·2		0·6

On looking at the column headed "Sum of Swings," we see that the numbers gradually diminish to the null position. Now, these numbers in each case correspond with the constant amount of induction 2 L, and must therefore be a measure of the sensibility of the arrangement of the bridge. The striking fact comes out that in this particular case the double null arrangement was that of least sensibility. The reason of this is not far to seek. In measuring resistance by the Wheatstone bridge the sensibility, for the same galvanometer and battery, depends upon the way in which the bridge is arranged. Now the effect of induction or capacity for variable currents is exactly comparable with that of a variable resistance, so that the bridge, although balanced for steady currents, may be regarded as deranged for variable currents, and the effect on the galvanometer will be greatest when the bridge is joined up for the measurement of resistance in the most sensitive way. It by no means follows that the most sensitive arrangement of the bridge will be the particular arrangement necessary for the null position.

It therefore becomes questionable whether the double null arrangement is worth the trouble of getting. Those who invariably perfer null methods make an assumption which is not true. They assume no less than the possession of a galvanometer of infinite sensibility. All they really have is one galvanometer which is the most sensitive at their disposal, and the best arrangement they can have is that which will, with that particular galvanometer, yield the most sensitive results. However, those who have an extremely sensitive galvanometer or an extremely unreliable battery can use this method of swings merely as an approximation to indicate the null position, and may thereby save much time.

There is a more important consequence of the fact that the extra current through the galvanometer is a linear function of the coefficients of induction and capacity. All Maxwell's comparative methods may be turned into absolute methods, and either Maxwell's absolute method, or, still better, the absolute method of Profs. Ayrton and Perry, can be applied to each one of them. Figs. 1 to 12 illustrate this.

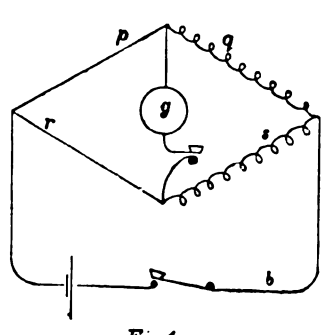

Fig. 1.

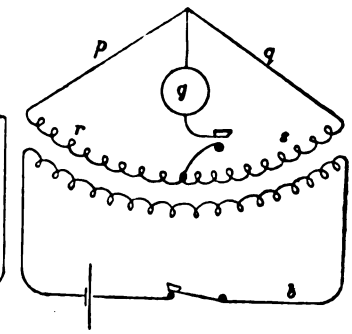

Fig. 2

Fig. 1 represents Maxwell's method of comparing two self-inductions, but we may regard the self-induction in the branch q as removed, provided we suppose that of the branch s to be

$$L_s - \frac{r}{p} L_q.$$

Fig. 2 represents Maxwell's method of comparing two mutual inductions. Fig. 11 represents the same method when the current runs through the bridge. For mere comparison it is better to use the arrangement of Fig. 2. For absolute measurement it is better to use the arrangement of Fig. 11. In the latter case we may regard the effective self-induction of the branch p as being

$$\frac{s+q}{s} M_{pb} \pm \frac{r+p}{s} M_{qb},$$

and we may regard the mutual induction as being altogether removed.

(To be continued.)

STORAGE BATTERIES IN PRACTICE.*

BY EDWARD P. ROBERTS.

Since I had the honour of reading a paper on storage batteries at the annual meeting of 1885, we have discarded storage batteries distributed in various localities as the source of supply of current to our incandescent lamps, and have now all lamps connected with our incandescent dynamos. Having, however, a large number of cells we have placed in position at our station about 1,200 of the same, charging them at night and using the stored current for day lighting and power, both of which are small in amount. In case of an accident to our machinery at night we could use our storage plant to tide over the time required for repairs, or until the majority of lights could be turned off. We have not yet had call, however, for such service, although we always have the batteries charged to a considerable extent before dark.

Since 1885 we have tried crockery and glass cells, with plates *suspended* in the same from glass rods and separated by glass rods from each other. This was a great improvement. The cells are placed on beams of a triangular cross-section, having a four-inch base, which, in turn, rest on glass insulators, Western Union pattern, screwed on pins fastened on cross pieces. The beams are first painted and then given a coat of paraffin. The insulation from cell to cell is much improved thereby. When lead cells are used they are placed on porcelain insulators on the beams; flat places being cut on the vertical angle of the beam.

I am informed, with what degree of correctness I do not know, that storage batteries have been much improved lately, over those with which I have had experience, but, even if such should be the case, I should hesitate to use them where gas lighting is cheap and where it might be desired to use only a *few lights* in *each* of a *large* number of localities separated by considerable distances. For special cases, however, I have no doubt the storage batteries can be used advantageously, particularly when the advantages of incandescent electric lighting are considered as being of financial value.

A few of the disadvantages arising from the conditions in the first part of the above paragraph are:—

1st. A large plant in each locality is needed because of possible drain on same. The ordinary use in a residence may be 15 lamp hours and the possible use 100 lamp hours. This is an extreme example, but is not exaggerated, as it was the necessary margin we had to provide when we had storage plants in each house requiring light for from 15 to 20 per cent. of our customers. If several customers can be supplied from one battery plant the margin of extra supply can be reduced. In such case

* Paper read at the meeting of the American Institute of Electrical Engineers, May 18th, 1887.

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it will be necessary *either* to connect all the customers on all the batteries connected in multiple arc, and then disconnect the batteries and charge same in series, or, if it is desired to use a meter system in which discharge bears a certain proportion to charge, an attendant must be ready to throw extra batteries on circuit needing same, and note name of customer using extra supply.

2nd. A large number of plants means a number of small stations to maintain and at which to keep supplies—distilled water, acid, &c.

3rd. With a number of small stations it is difficult to regulate E.M.F. to current desired. However small the percentage of E.M.F. lost in the discharging wires the E.M.F. of the batteries should rise as lamps are turned on, or the lamps will be below candle-power, when a number are used, if for one or two the proper E.M.F. is used ; or it will be necessary to strain the lamps when a few are used, in order to have normal brilliancy when a number are desired. To still further complicate matters, the E.M.F. is higher at the start, particularly if only a few lamps are "on," than it is later in the evening. These differences in E.M.F. are small, but are sufficient to vary the candle-power of the lamps.

If, therefore, each customer is connected with one or more batteries for his sole use the following takes place :—As darkness approaches one or two lights are turned on and are raised to abnormal candle-power straining lamps and making consumers di satisfied with any less light later on, and as the customer's eyes become tired the light drops, possibly not below the normal candle-power, but the *comparison* is bad, and it requires considerable power of persuasion on the part of the company's "talker" and loss of his time as a "worker" to make the customer believe that his eyes are at fault and not the light. It may be that an entertainment is given in the house, and then the drop of candle-power is more noticeable, although it may not fall much below the normal.

Of course it is possible to design mechanism to overcome all such troubles, to throw in extra cells and extra batteries as required, &c. To design mechanism to accomplish such work with reliability, and which will not be too costly for maintenance or prohibitory on account of excessive first cost, is undoubtedly a problem. Matters are further complicated by the necessary use of charging mechanism. Also, it is desirable to have switches so arranged that it will be impossible to have charging current "on" when lights are being used *from* a battery. The writer has run 1,000 lights in such a manner (with charge on) for over a year, but does not advise it from any standpoint except necessity.

If a few large stations are used the E.M.F. at same can be readily shown at main station, and regulated from same if desired, or an attendant can be sent to any station needing regulation.

My experience teaches me that if batteries can be charged under inspection and allowed to have a discharge without excessive variation in amount of same, that the batteries will give *much more reliable* results than in any other way. The nearer this can be approached the more satisfactory will be the service.

If, therefore, it seems to be advisable in any city to erect a storage battery system for general distribution, I believe it will be found best to erect a very few large battery stations at the various centres, and that the interest on the extra cost of the wire leading from the same to the lamps, over what would be necessary if each light were close to a battery, will be far more than saved in the lessening of attendance alone, and that the avoidance of other evils I have mentioned will thus be clear gain.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subject. connected with Electrolysis :—

ON THE MIGRATION OF IONS AND AN EXPERIMENTAL DETERMINATION OF ABSOLUTE IONIC VELOCITY.

BY DR. OLIVER LODGE.

(Concluded from page 104.)

Experiment on the travelling of hydrogen.

August 17.—The same apparatus as in Fig. 10 was again used, but the solutions arranged as follows :—In cathode vessel, sat. solution of $CuSO_4$ as before ; in anode vessel, dilute sulphuric acid ; in tube, the following : 49 cc. of sodic chloride sol. (5 grammes salt in 100 water) with 1 cc. of baric chloride sol. ($BaCl_2$, 2Ag centigrammes, or 2·44 of the crystallised salt, in 100 cc. water) ; add to this a little phenol-phthallein, and just enough NaHO to make it red. The destroying of the colour is the thing observed. No measurements made till the liquid is discoloured round the bends of the tube. At xvii. 43 the current was started, with an E.M.F. of 45 volts between terminals. The galvanometer deflection increased from 41·1° to 44·2° in the first half hour, and then increased further to 46° in the next hour. By xvii. 51 the decolorisation had got round the bends, and the first or starting mark was made. The progress of the whole experiment was rapid.

Time.	Current in milliamperes.	Progress of SO_4.	Progress of H.
xvii 51	7·8	0	0
,, 56	—	0·5	1·45
xviii 6	—	1·15	3·65
,, 16	—	1·65	5·33
,, 26	8·7	2·2	6·9
,, 36	8·8	2·6	8·5
,, 46	9·0	3·15	10·05
,, 56	·91	3·8	11·6
xix 6	·92	4·4	13·21
,, 16	·93	4·9	14·79
	Current stopped.		
,, 26	0	4·98	15·13
,, 36	0	4·98	15·35
,, 46	0	4·98	15 51
xx 56	0	4·98	15·59
6	0	4·98	15·61

In the preceding summary the column headed 'Progress of SO_4' gives the position of the marks made near cathode end of the tube. The column headed 'Progress of H' gives the position of the marks made near the anode end. By these headings it is not intended to insist that the full theoretical meaning of the observations is the same as the obvious and apparent meaning. All distances are specified in centimetres.

The progress of the experiment is represented pictorially in Fig. 13.

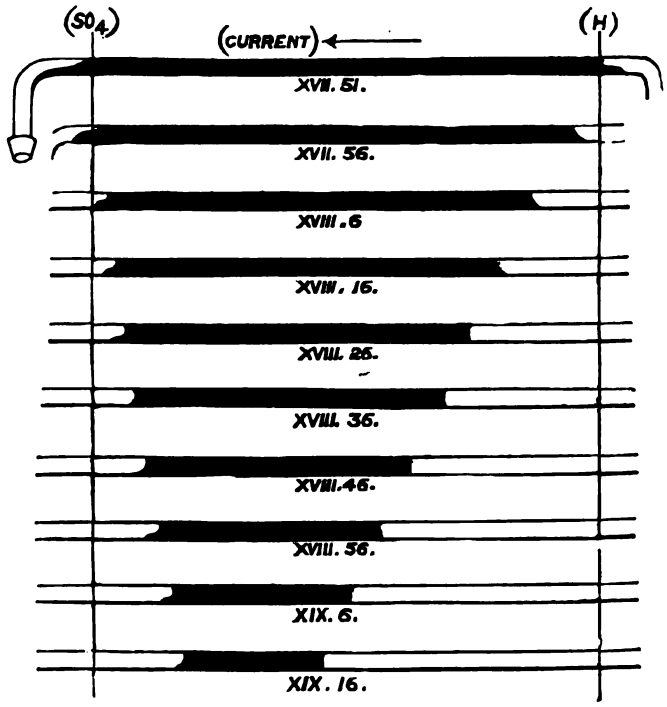
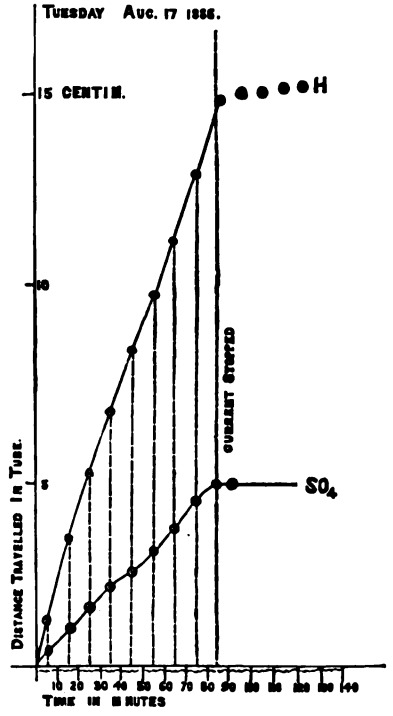


FIG. 13.

Horizontal lengths are drawn to scale, viz. : 1-4th real size.



Plotting of these numbers.

FIG. 14.

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August 18.—Another similar experiment, but with a little more NaHO added to liquid in tube to make colour more distinct. No good observation could be obtained of the SO_4 progress this time, as it did not get up to the bend, but the H progress was read. The tube was graduated in millimetres for this experiment. 45 volts applied.

Time.	Readings of decolorisation boundary, as it proceeds from anode end.	Galvanometer readings.
	Centimetres.	
xv 0	—	40·5
,, 55	28·2	41·3
xvi 5	26·35	42 3
,, 15	24·93	42·8
,, 35	22·07	43·5
,, 55	17·21*	44·0
xvii 15	16·32	44·7
,, 40	12·71	45·9
,, 50	Current stopped.	
xviii 0	10·9 and 10·1	0
,, 10	10·8 ,, 9·8	0
,, 20	10 6 ,, 9·3	0
	Current started in reverse direction.	
,, 33	10·3 ,, 8·8	—
,, 43	9 5 ,, 7·8	—
,, 53	about 9·5 and 7·8	—
	Boundary getting indistinct.	

* It would seem probable that there was some unknown misreading here; probably 7 for 9.

The double number in the middle column represents the two ends of a slope into which the boundary threw itself as soon as the current was stopped; indicating convection. A galvanometer deflection of 45° means a current of ·009 ampere.

In the last experiment the tube was not perfectly horizontal, and this may have caused some disturbance. In future experiments the tube was carefully levelled to begin with.

Experiment on velocity of copper.

August 24.—Started an experiment with $CuSO_4$ in both vessels, and in tube some NaCl with a little K_4FeCy_6. But the indicator did not form a sharp boundary across the tube, and the experiment was not very satisfactory. 65 volts applied.

		Current in milliamperes.
At xi 15	Current started	10·0
,, xiv 37	Reading on tube was 29·3	—
,, xvi 7	,, ,, 21·8	—
,, xvii 37	,, ,, 18·7	8 9
,, xviii 37	,, ,, 17·3	8·7

Experiment on the velocity of hydroxyl.

August 25.—Made an experiment on the rate of travel of the hydroxl radicle of NaHO, by using the closed $CuSO_4$ vessel with copper electrode as *anode* vessels and putting a solution of soda in the open (now) cathode vessel. The tube contained NaCl (5 grammes in 100 cc.) with a little phenol-phthallein not coloured as yet with alkali. The appearance of colour was the thing to be observed as the HO travelled against the current and attacked the NaCl. 65 volts applied to electrodes. Tube 40·7 cm. long. For diagram of results see Fig. 16.

Time.	(Progress of HO). Reading on tube.	Current in milliamperes	Time.	(Progress of HO). Reading on tube.	Current in milliamperes.
x 50	Tube inserted	0	xiii 39	12·4	11·2
xi 15	Current started	9·4	,, 59	9·58	11·4
,, 39	29·0	10·3	xiv 1	9·30	Current stopped
xii 9	27·0	—	,, 11	8·8	0
,, 19	25·18	10·4	,, 21	8·49	0
,, 39	21·7	10·6	,, 31	8·26	0
,, 59	18·3	10·8	,, 41	8·0	0
xiii 19	15·1	11·0	,, 53	7·72	0

Another experiment on the velocity of hydrogen.

August 25.—Closed vessel with $CuSO_4$ used as cathode vessel again, open vessel containing dilute H_2SO_4.

Tube containing NaCl (5 to 100) with a little phenol-phthallein and a touch of NaHO as before.

This experiment seemed to go well. The numbers are plotted in Fig. 16.

Time.	Reading on tube.	Current in milliamperes.	Time.	Reading on tube.	Current in milliamperes.
xv 47	Current started	9 4	xvii 36	10 80	12·0
,, 56	29·19	—	,, 56	6·83	12·3
xvi 6	27 00	10·4	,, 58	6·43	Current stopped
,, 16	25·15	10·6	xviii 10	6·00	0
,, 36	21·65	11·0	,, 20	5·85	0
,, 56	18 06	11·1	,, 30	5·65 to 5·3	0
xvii 16	14·50	11·4			

Successive appearances of the tube are shown in Fig. 15.

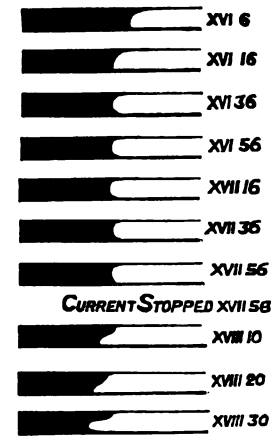
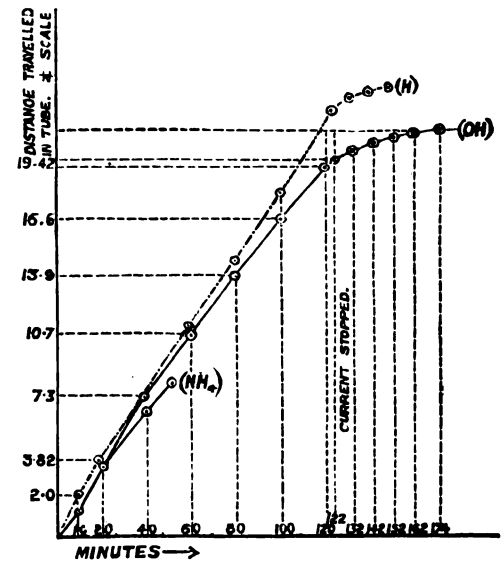


FIG. 15.



Plotting of the last four tables.

FIG. 16.

Experiment on the velocity of ammonium.

August 26.—Made several attempts to get the speed of NH_4 using Nessler solution. The indicator is not very distinct: no precipitates seem to work well as indicators; they introduce disturbances. Fluid detectors answer better.

Ammonic sulphate was put in anode open vessel.

The tube contained NaCl + Nessler solution. 65 volts supplied.

Time.	Reading on tube.	Current.
xiii 29	Current started.	—
,, 36	28 05	10·2
,, 46	26·10	—
,, 56	24·25	10 4
xiv 6	22·70	—
,, 16	21·30	10·5
,, 26	20·20	10·4
	Current stopped.	
,, 36	20·1	0

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Current stopped because boundary was getting indistinct. This did not seem a very good experiment, but it is better than some here unrecorded which preceded it.

August 26.—A similar experiment with a drop of phenol-phthallien added to liquid in tube, because its indication is sharper. Boundary, however, still sloping, and therefore unsatisfactory to read.

Time.	Reading on tube.	Current.
XIV 48	Current started.	10·1
,, 54	27·55	—
XV 4	24·4	—
,, 14	22·3	10·6
,, 24	20·55	—
,, 34	19·1	10·6
	Current stopped.	

Further experiments on the meeting of Ba *and* SO_4 *in jelly tubes.*

It may be remembered that, whereas in free liquid, Ba appeared to travel about three times as fast as SO_4, the precipitated plug of $BaSO_4$ nearly always appearing much nearer the Na_2SO_4 or cathode end of the tube than near the $BaCl_2$ end, yet in jelly tubes they appeared to travel at about the same rate, the plug of precipitate forming near the middle of the tube. To make sure that there was no error of observation here, and to see if constitution of jelly affected the matter, a few experiments with jelly tubes were repeated, and different strengths of jelly were used.

August 24.—Two tubes, each 40 centimetres long, were filled with jelly made by dissolving 40 grammes of gelatine in 150 cc. of dilute acetic acid, of strength one centigramme molecule in 5 cc.

Another pair of similar tubes were filled with jelly made with 40 grammes of gelatine dissolved in 150 cc. of four times weaker acetic acid, viz , a centigramme molecule in 20 cc.

58 volts were applied to the carbon electrodes of all four tubes. The anode and cathode vessels contained $BaCl_2$ and $CuSO_4$ respectively.

In the tubes with weak acid, $BaSO_4$ began to form in 28½ hours after starting the current, and its position was 19·3 in one tube, and 19·2 in the other, from the $BaCl_2$ end, and therefore 19·7 and 19·8 from the Na_2SO_4 end.

In the tubes with stronger acid the precipitate took some hours longer to form, and its position was 19·2 in one tube, and 18·3 in the other, from the barium end. The relative speed of travel of Ba in the two pairs of tubes was taken by making simultaneous marks on each tube as the Ba proceeded ; and the ratio of these rates was in the weak acid tubes 1 21 times that in the stronger acid tube.

Thus, although the absolute speed is less in the stronger acetic acid jelly (as is quite right, because its conductivity is less ; see above), the ratio of speeds of Ba and SO_4 remains practically unity in both.

August 27.—To confirm, the four tubes were started again in just the same way, except that, while one pair contained jelly with $C_2H_3O_2$ centigramma molecules in 5 cc. as before, the other pair contained jelly with $C_2H_3O_2$ centigramme molecules in 40 cc. The distance travelled by Ba in the weak acid jelly tubes was 15·3 cm., and in the strong acid jelly tubes was 12 4 in the same time ; giving a ratio 1·20 as before.

So far as it is wise to draw a moral from unfinished experiments it may be said that, while there are some divergencies, yet they are in the main confirmatory of the theory of Professor F. Kohlrausch, especially in the case of the velocity of hydrogen ; and I think it may be regarded as a noteworthy instance of scientific prediction if numbers calculated theoretically from conductivity data be found to agree at all closely with the results of direct experiment.

In conclusion I wish to record my best thanks to my assistant, Mr. Edward Robinson, for the care and assiduity he has bestowed upon these experiments. As I have had occasion to remark in the course of the paper, he has not only carried out my proposals with ingenuity and skill, but he has in several cases modified details and devised fresh combinations.

CHEMICAL SOCIETY.

ON A NEW CLASS OF VOLTAIC COMBINATIONS IN WHICH OXIDISABLE METALS ARE REPLACED BY ALTERABLE SOLUTIONS.

The following is an abstract of an interesting paper read at a recent meeting of the above society by Dr. C. R. Alder Wright and Mr. C. Thompson :—

It appeared to the authors probable that just as a liquid capable of parting with oxygen, chlorine, &c., can be used in conjunction with an electrode of unchangeable material at one side of a voltaic cell (as in Grove's nitric acid battery and analogous combinations), or may be replaced by a solid conducting electrode, itself capable of losing oxygen (*e.g.*, a plate of strongly compressed peroxide of lead), so conversely might a conducting plate of oxidisable material (*e.g.*, zinc) at the other side be replaced by an unchangeable electrode in conjunction with a liquid capable of taking up oxygen, chlorine, &c., without producing any fundamental change in the character of the actions taking place in the cell whilst generating a current. The electrode immersed in this oxidisable substance, like the zinc of an ordinary cell, would acquire the lower potential, and the opposed plate the higher potential ; *i.e.*, the wire connected with the latter would be the "positive pole" of the construction in reference to the external circuit.

On trial, it has been found that such is the case, and that in consequence a large variety of novel forms of cell becomes easy of construction. For example, sodium sulphite or potassium ferrocyanide solution opposed to chromic-sulphuric acid solution ; preferably with an intermediate layer of some neutral salt solution, such as sodium sulphate, to prevent the direct action of the two fluids on one another. During the passage of a current, sodium sulphate or potassium ferricyanide is formed in quantity proportionate to the electricity passing, *i.e.*, to the amount of silver thrown down in a silver voltameter included in the circuit ; whilst chromium sulphate is produced at the other side. Various analogous cells are described, in particular one where lead oxide dissolved in caustic soda is opposed to alkaline hypobromite. In this case lead dioxide is produced and separates out in the solid form ; and one where chromium sesquioxide dissolved in caustic soda is opposed to chromium trioxide dissolved in sulphuric acid. Here sodium chromate and chromium sulphate are formed, an E.M.F. about equal to that of a Daniell cell being set up.

In the discussion which followed,

Mr. PAGE said that after listening to Dr. Wright he was able for the first time to understand how electric currents might arise in the animal body.

Dr. ALDER WRIGHT said in reply to Mr. Page that the experiment suggested of opposing venous and arterial blood had not been actually tried by him as yet, but he thought it quite probable that a weak current might be produced. [The PRESIDENT subsequently said that he had been told—he believed by Mr. Peter Squire—that a current was produced on opposing venous and arterial blood.] By opposing alkaline pyrogallol solution to oxidising agents, notable currents could be developed ; and various other organic compounds might be used instead of pyrogallol. With certain organic bodies, however (*e.g.*, chloral hydrate), attempts to produce oxidation in cells had hitherto failed. The opposition of acid and alkaline fluids alone would not necessarily produce more than infinitessimal currents ; Becquerel's "*pile à oxygène*" (nitric acid opposed to caustic potash solution) gave rise to decomposition of nitric acid and evolution of oxygen from the electrode immersed in the alkali ; other authors had found that analogous cells with chromic-sulphuric acid instead of nitric acid would behave in the same way and develop a continuous current capable of doing external electrolytic work such as deposition of silver in a voltmeter ; on the other hand, a cell in which caustic soda and sulphuric acid only were opposed (so that chemical action other than neutralisation could not take place) would only develop an infinitesimal current through a silver voltameter, capable of depositing only traces of silver even after some days, although its E.M.F. measured by an electrometer was considerable.

With regard to the observations of Dr. Armstrong, he would say that whilst without doubt Grove's gas battery was the prototype of the class of cells discussed, inasmuch as that combination was virtually an oxidisable solution of hydrogen opposed to an oxidising solution of free oxygen still the examination of cells in which other oxidisable fluids were used instead of hydrogen solution, and other oxidising substances besides solution of oxygen, was a branch of experiment in which hardly anything had hitherto been done, and which seemed to merit some little attention. The authors desired to study in detail the general behaviour of certain typical classes of cells in which actions of the kind take place, especially from the point of view of elucidating the precise chemical changes going on and their relations to the amounts of electrical (or current) energy developed. Whilst there was not exactly a probability of any very startling discovery being made, there were still a number of points of interest connected with the subject worth examining ; and although the hope of an improved primary battery based on actions of this kind for commercial use, as suggested by the President, was perhaps not yet within measurable distance, yet the problem of economically obtaining current energy by direct chemical action (and especially by oxidation) was one now attracting considerable attention, and it was impossible to predict what might or might not be the result of systematic experiments tending in that direction. The importance of obtaining practically usable currents from coal direct without the use of the steam engine and dynamo could hardly be over-rated should it hereafter be found practicable so to do ; and in view of the compactness of the animal machinery, whereby the oxidation of fuel in the form of food gave rise by muscular action to mechanical energy, it did not seem to be of necessity hopeless to attempt to solve such a problem.

PHYSICAL SOCIETY.—June 11.

Mr. SHELFORD BIDWELL, F.R.S., Vice-President, in the chair.

A number of Puluj and other vacuum tubes were exhibited by Dr. Warren De la Rue. The Puluj tubes consisted of a phosphorescent lamp, and radiometers with phosphorescent vanes and mica discs painted with phosphorescent substances. The other tubes contained different phosphorescent minerals, such as magnesium carbonate, calcium silicate, and Iceland spar. When illumined by a large induction coil beautiful colour effects were produced.

The following papers were then read :—*Note on Beams Fixed at the Ends*, by Profs. AYRTON and PERRY. This paper was not of an electrical character.

Note on Messrs. Vaschy and Torranne's Method of Comparing Mutual Induction with Capacity, by Prof. G. C. FOSTER. In November last the

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author described a method of comparing the mutual induction of two coils with the capacity of a condenser. Since then he has found that a very similar method was used by Messrs. Vaschy and Torranne in July, 1886, and published in *The Electrician* the following month. The formulæ are identical, and the difference consists in interchanging the galvanometer and the variable resistance *p*. Messrs. Vaschy and Torranne's arrangement has the advantage that the resistance of the secondary coil need not be known. Prof. Foster's method had been used by one of his students (Mr. Draper) about two years ago, but priority in publication belongs to Messrs. Vaschy and Torranne.

Prof. PERRY asked the meeting for suggestions to explain why a strip of steel twisted about its longitudinal axis at a red heat and allowed to cool tends to untwist when under tension? and for a formula to calculate the amount.

A Note on Magnetic Resistance, by Profs. AYRTON and PERRY, was postponed.

COMPANIES' MEETINGS.

The Northern District Telephone Company.

The fifth annual general meeting of the shareholders of the Northern District Telephone Company was held at the offices of the Company, Arcade-chambers, on 13th inst.

After the report of the Directors and statement of accounts had been read and adopted,

The CHAIRMAN (Mr. R. T. Wilkinson) pointed out the very satisfactory progress which the Company had made since the beginning of the present year. In view of the great dulness in trade, and the consequent reluctance on the part of firms to increase their expenditure even by so small an item as an annual telephone rental, he considered the number of subscribers to the company's exchanges to have increased with a rapidity which was extremely satisfactory, the total number at the end of 1886 showing the increase for the 12 months to have been at the rate of no less than 71 per cent. Adverting to the recent increase in the Company's capital from £100,000 to £2.0,000, the Chairman pointed out, as an instance of the confidence shown in the Company, that the whole of the new capital had been taken up immediately it was issued. This he considered to be extremely gratifying. He was also glad to see that a very considerable extension of the system had been carried out, and he had every reason to believe that it would soon make them a very remunerative return. He felt certain that the year 1887 would prove equally as satisfactory to the shareholders, in the matter of increased business, as the last year had, and that notwithstanding the continued depression in trade. The payment of the preference dividends having been confirmed, and the usual vote of thanks to the Chairman passed, the meeting terminated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 10th June amounted to £4,151.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 10th June were £3,4?4, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE EASTERN TELEGRAPH COMPANY (LIMITED).—According to an advertisement which appears elsewhere, the directors of this company are prepared to issue £4 per Cent. Perpetual Debenture Stock for debentures falling due 1st August, 1887 (bearing interest from 1st May, 1887), in exchange for equal amounts of the company's Five per Cent. Debentures falling due 1st August, 1887, with the coupon due that day attached, and to pay £1 in cash in respect of the said coupon if the debentures are deposited at the company's office on or before 1st of July, 1887. Debentures not so deposited will be paid off at par on 1st of August at the company's bankers, Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, London. The Mortgage Debenture Stock constitutes a first charge on the undertaking and revenues of the company. The amount issuable is by the special resolution creating the same restricted to one-third of the share capital from time to time issued and paid up. The stock is at present quoted on the London Stock Exchange at the price of 101 to 103 per cent.

UNITED TELEPHONE COMPANY'S DIVIDEND.—The directors of this company recommend a dividend for the second half-year ending the 30th April last at the rate of 8s. per fully paid share (part paid shares receiving in proportion), making, with the interim dividend paid on the 26th November last, a total dividend for the twelve months ending 30th April last of 13 per cent. For the second half year ended 30th April, 1886, the dividend was 9s. per share, making a total distribution for the year of 13 per cent.

NOTICES OF REMOVAL.—Notice is hereby given that on and after Monday, the 20th inst, the offices of the Brazilian Submarine Telegraph Company and those of the African Direct Telegraph Company will be removed to Winchester House, 50, Old Broad-street, E.C.

PERSONAL.—Mr. W. Brooks Sayers has commenced business as a consulting and electrical engineer at Birmingham. This gentleman is well-known in electric lighting circles in London his connection with this industry being of long standing.

SUBMARINE CABLE COMPANIES.

(Compiled by LEWIS WELLS.)

Name of Company.	Capital.	Cable Mileage	Revenue including Subsidies	Reserve and Sinking Fund.	Dividends per cent. on Ordinary Capital.	Market price of Ordinary Capital, June 9, '87.
	£		£	£		
African Direct	475,000	2,739	30,000	Nil.	New Company	*
Anglo-American....	7,000,000	10,437	200,026	966,906	½ per cent.	36 %
American Telegraph and Cable.....	2,800,000	5,537	80,700	†	5 ,, ‡	*
Black Sea	130,000	351	9,802	Nil.	4 ,,	*
Brazilian Submarine	1,450,000	7,326	171,688	87,292	6 ,,	11½—¾
Commercial Cable..	1,600,000	6,937	110,000	†	Nil.	*
Telegraph de Paris à New York.....	1,680,000	3,409	48,122	54,571	Nil.	*
Central and South American	1,000,000	3,178	†80,000	†	?	*
Cuba Submarine....	220,000	940	37,352	66,500	8 per cent.	12—½
Direct Spanish	143,724	699	20,032	3,577	Nil.	2¾—3
Direct United States	1,214,200	2,983	48,048	328,183	2 per cent.	9—½
Eastern	5,825,000	19,220	633,634	540,616	5½ ,,	10⅜—⅝
Eastern and South African	950,000	4,554	131,305	115,653	6 ,,	*
Eastern Extension..	3,366,600	13,022	441,799	604,032	6 ,,	11½—¾
German Norwegian.	82,240	252	6,383	345	5 ,,	*
German Union	330,000	1,119	44,420	67,738	8½ ,,	10½—11
Great Northern	1,840,000	6,108	280,408	470,306	7½ ,,	13¼—14
HamburgHeligoland	10,500	40	950	204	5 ,,	*
London Platino Brazilian	483,480	1,058	21,059	10,867	3 ,,	4—¼
Mexican	200,000	709	†20,000	†	?	*
Montevidean and Brazilian	105,270	200	2,370	4,570	¾ per cent.	*
River Plate	55,500	32	†10,000	†	?	*
Spanish National ..	237,190	2,159	7,264	Nil.	Nil.	*
Submarine	338,225	803	132,681	203,819	13¾ per cent.	180—190 %
West African	530,590	2,825	†	Nil.	New Company	4½—5½
West India and Panama.....	1,325,530	4,119	83,365	126,284	Nil.	⅝—¾
Western & Brazilian	1,498,650	2,543	125,253	135,501	£3. 9s. 4d. %	8—⅛
West Coast of America.....	450,000	1,699	43,026	15,000	2 per cent.	4⅜—⅝
	35,341,699	104,998	2,819,687	3,801,974		

* Not dealt in on London Stock Exchange.
† No information published. Accounts not obtainable. Revenue estimated.
‡ 5 per cent. guaranteed by Western Union Company.

[The above table, for which we are indebted to the courtesy of the compiler, will be found valuable for purposes of comparison, and in any discussion of questions relating to cable work. We hope periodically to insert the table with the necessary alterations.—ED. *E.*]

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 15.		BUSINESS DONE WEEK ENDING JUNE 15. Highest.		Lowest.
Anglo-American	35,	36	..... 35½		35
Do. Preferred	57½,	58½	..... 58⅜		57½
Do. Deferred	13½,	14½	..... 14½		13½
Brazilian Submarine	11⅛,	11⅜	..... 11⅜		11 3-16
Cuba	12,	12½	..... 12½		12
Do. Preference	18,	19	..... —		—
Direct Spanish	2¾,	3	..... 2¾		—
Do. Preference	7½,	8½	..... —		—
Direct United States Cable	8¾,	9½	..... 8¾		8¾
Eastern Telegraph	10⅝,	10⅞	..... 10⅞		10 11-16
Do. 6 per Cent. Preference.....	14,	14½	..... 14 1-16.....		14
Do. 5 per Cent. Debentures, 1899 ..	107,	110	..... —		—
Eastern Extension	11⅜,	11⅝	.....11 11-16		11 7-16
German Union	10½,	11	..... —		—
Globe Telegraph and Trust.....	5⅜,	5⅝	..... 5⅜		5⅜
Do. Preference	12¾,	13½	..... 13½		12¾
Great Northern	13¾,	14	..... —		—
Indo-European	34,	35	..... 35		—
Reuter's	7⅞,	8½	..... —		—
Submarine	180,	190	..... —		—
West India and Panama	⅝,	¾	..... 11-16.....		⅝
Do. 1st Preference.....	8½,	9	..... 8¾		—
Western Brazilian	8,	8½	..... 8½		—
Western Union 7 per Cent. 1st Mortgage	120,	125	..... —		—
Do. 6 per Cent. Sterling Bonds.....	104,	107	..... —		—

TELEPHONES.

Consolid. Telephone and Maintenance..	⅜,	½	..... —		—
Oriental	⅛,	⅜	..... ⅛		—
United Telephone	12½,	13½	..... 13⅜		13

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)..	2⅜,	3⅛	..... 2 15-16.....		2 13-16
Do. (fully paid)	4,	4½	..... —		—
Swan.....	1½,	1½	..... 1⅝		1½
Maxim Weston	3-16,	5-16	..... —		—

MISCELLANEOUS.

Telegraph Construction	36,	37	..... 36¾		35¾
India Rubber, Gutta Percha, and Telegraph Works	23,	24	..... 23½		—

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NOTES.

ALFORD.—Tenders are asked for lighting the town of Alford "with gas or other light." Particulars may be obtained from the town clerk.

OUR AMERICAN COUSINS.—CORRECTION.—In our last week's leading article the date of the foundation of the Society of Telegraph-Engineers was given as 1878. It should have been 1871.

SOFT STEEL FOR COMMUTATOR BARS.—In the description of an electro-motor designed in the United States by Mr. F. Baxter, we find that the commutator bars are made of soft steel instead of copper.

THE MONTMARTRE CENTRAL STATION.—The central station of the Compagnie Francaise d'Eclairage Electrique, in the Faubourg Montmartre, Paris, commenced operations at 9:30 p.m. on the 21st inst.

PROJECTED TELEPHONE LINE BETWEEN HAVRE AND ANTWERP.—Suggestions for long distance and international telephone lines continue to multiply across the Channel. The latest proposal is for a line between Havre and Antwerp.

EXETER.—It is stated that an electric lighting company is about to make a start at Exeter. Water power is to be used, and the company proposes to light a number of main streets gratis for several months. We presume that the Thomson-Houston system is the one alluded to.

TENDERS WANTED.—Tenders are asked for the supply of telegraph material and apparatus, including galvanised wire, by the Highland Railway Company. Forms of tender may be obtained on application to Mr. J. G. Bulmer, storekeeper, Inverness, and must be returned by the 25th inst.

TRANSFORMERS IN THE STATES.—The Westinghouse Electric Light Company, Pittsburgh, Pa., has received the contract for a large transformer plant to be erected at Denver, Col., and to consist of 6,500 lights. The station will be supplied with five dynamos, with a capacity of 1,300 lights each.

SCIENCE AND THE JUBILEE HONOURS.—This is a chapter of "Snakes in Iceland." The Royal Society received six tickets for the service at the Abbey, and this is all that can be said—so far, at least—for the recognition which has been accorded to the representatives of Physical Science on the Jubilee of Queen Victoria.

OBITUARY.—We regret to record the death, at the age of 76, of Colonel Alexander Agnus Croll, of Beechwood, Reigate, who was one of the pioneers of cheap telegraphy. At the time of the transfer of telegraphic business to the Post Office, Colonel Croll occupied the position of chairman of the United Kingdom Electric Telegraph Company.

DAMASCUS.—The Governor-General of Damascus is busy with plans for laying tram lines through the streets of that ancient city. It has afforded us pleasure, therefore, to send His Excellency certain copies of this journal, which set forth the advantages of electricity over other forms of locomotion for the purpose in view. The population of Damascus at the present time exceeds 200,000.

ROTTERDAM.—Messrs. R. E. Crompton and Co., on behalf of their agents, Messrs. J. Van Zwieten and Co., have contracted with the Dutch Government to deliver a complete search light plant for the torpedo launch "Batak." We are also informed that the plant supplied by the same firm for lighting the brewery of Messrs. Boartz and Sons at Rotterdam is to be extended so as to light the whole range of buildings.

THE PATENT LAWS.—In a paper read before the Institute of Patent Agents, on the "Compulsory Working of Patents," Mr. A. V. Newton, Fel. Inst. P.A., argues "that the provision for the compulsory working of patents is a mistake, because it discourages inventors from rather than urges them towards the establishment of new branches of manufacture, by destroying the incentive to foreign inventors to create a demand for imported inventions."

ASBESTOS DEPOSITS IN RUSSIA.—It is stated that extensive deposits of asbestos have recently been discovered in the neighbourhood of Orenburg, while near the Verkni Tagil ironworks is a hill called the "Sholkovaya Gora," or Hill of Silk, which is stated to be largely composed of asbestos. The mineral is said to be of the best white quality, and adapted for all important purposes to which asbestos is applied. In the Goroblagsdat district of Perm, similar deposits, it is said, crop above the surface.

THE PROPOSED ELECTRIC LIGHTING OF BUCHAREST.—A Bucharest correspondent of a daily paper says that the negotiations carried on for some time between the gas company there and the municipal authorities have fallen through. The municipality favours the idea of introducing electric lighting, for the production of which a fall of water near Cotroceni would afford motive power. Before coming to a definite decision, however, the authorities have consulted a German engineer, and at present they are awaiting his report.

THE JULIEN TRAM CARS AT HAMBURGH.—In another column will be found an extract from an interesting and encouraging report of the cost of working the Hamburgh tram lines by means of Julien storage cars. This report is based upon a careful record of the expense during the eight months ending in December last. But according to a statement which we recently quoted from the *La Lumière Electrique* the system has now been or is about to be abandoned altogether. We should be glad to learn the truth upon this point.

MENDING INCANDESCENT LAMP FILAMENTS.—M. Pauthonnier has succeeded in repairing the filament of a large number of incandescent lamps, at a cost which is said not to exceed 2f. per lamp. His method is to open the lamp with great care, so as to prevent a too sudden rush of air, which would shatter the glass, and then to displace the air by a dense hydro-carbon. The broken ends of the filament are brought into contact, and a current is sent through which causes a deposition of carbon sealing up the joint and strengthening the filament throughout its length. It would, however, seem that the process must necessarily tend to lower the voltage of the lamp.

A NEW RELAY.—A very simple and sensitive relay has been designed by M. Lahmayer, the construction of which will easily be understood from the following description:—A glass tube closed at both ends is about half filled with mercury, and contains a piece of iron rod nearly the full width of the tube, which floats in the mercury. A pair of platinum wires enter the glass just above the normal level of the mercury, and are connected with the circuit to be closed by the action of the relay. The glass tube is placed within a solenoid traversed by the current in the first circuit. The iron float is sucked down by the solenoid; the mercury rises and closes the circuit through the platinum wires. To avoid the oxidation of the surface of the mercury by the spark on breaking contact, the upper part of the tube is filled with nitrogen.

THE ELECTRIC LIGHT FOR THE FRENCH ARMY.—A portable electric light apparatus has been for some time in use in the German army. For the field equipment the dynamo, engine, and projector are mounted upon a carriage drawn by several horses, and a stationary apparatus of the same character has been

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supplied to most of the fortresses on the frontier. It is announced, however, that the French Government has decided to adopt a far more powerful light, and the optical arrangements of the projector are designed especially to produce the most dazzling effect upon the eyes of the troops upon whom the beam is directed. The carriage upon which the apparatus is mounted is also provided with a gun whose special function will be to fire at the lamps of the enemy while their light is overpowered by the more brilliant beams of the new projector.

THE COST OF ELECTRIC LIGHT AT SALZBURG. — The *Electricitätswerke* of this town have issued the following scale of prices for the supply of the electric light :—For 16 candle-power incandescent lamps about ·94d. per hour; 25 ditto, 1·47d.; 35 ditto, 2·00d.; on which a discount will be allowed varying from 5 to 25 per cent., according to the number of hours per day that they are in use. For arc lamps the prices are :—From 400 to 500 candle-power, 2·82d. per hour; 600 to 700 ditto, 4·23d.; 800 to 900 ditto, 5 64d.; 1,400 to 1,600 ditto, 8·46d. It is intended to supply arc lamps in pairs only, and if a single lamp be required, double the ordinary price will be charged for it. The carbons will be supplied by the company, and will cost about ·705d. per lamp per hour. The current supplied is to be measured by a current meter, to be approved by a committee appointed by the magistrates, and the yearly rent charged for these meters will be :—Up to 10 or 16 candle-power incandescent lamps, £1. 9s. 4½d.; 25 ditto, £1. 19s. 2d.; 50 ditto, £2. 18s. 9d.; 100 ditto, £3. 18s. 4d.—*Journal für Gasbelenchtung.*

THE NEW AUSTRIAN CUSTOMS TARIFF AND THE IMPORTATION OF DYNAMOS.—Owing to the operation of the new Austrian tariff, which came into force on the 1st inst., special precautions will be necessary, says *Industries*, in the importation of dynamos. As the tariff now stands, these machines, if imported complete and ready for work, will have to pay a duty of £24 per ton, the duty being calculated as if the whole of the weight were made up by cotton-covered wire. Such a duty would evidently be prohibitive, and, to avoid it, foreign manufacturers are permitted to import dynamo machines in parts, when each component part will be charged the duty according to the material preponderating in its construction. Machinery and apparatus containing by weight 75 per cent. of wood pay £5 per ton; machinery and apparatus containing over 50 per cent. of base metals other than iron or copper wire pay £15 per ton; other portions of machinery not containing wire pay £8. 10s. per ton. If machinery is imported in parts which require to be finished before being fitted up, it is taxed at a slightly reduced rate as compared to the above.

GLOBE LIGHTNING IN FRANCE.—In a note communicated to the Academy by the Minister of Posts and Telegraphs, some extraordinary events are described which happened in connection with a thunderstorm in the neighbourhood of Mortrée (Orne), on April 24th. A cow was being milked in a stable when the animal suddenly stood on its hind legs, jamming its fore-feet between the bars of the rack, and at the same instant the affrighted peasant saw a ball of fire enter the open door, pass between the legs of the cow, and disappear without explosion, and without damage. In the street outside the ground was at the same time thickly covered with fragments of a soft, greyish-white mineral substance, varying in size from that of a pea to a walnut. No analysis of the substance is given. During the same storm a length of 150m. of telegraph wire was destroyed, the wire being broken up in numerous short fragments. The discharge entered the telegraph office at Mortrée, and passed to earth through the lightning protector with a tremendous detonation, but without doing any damage whatever. At the same time a portion of the discharge seems to have passed through the brick wall of the house, perforating several holes, and hurling a quantity of plaster to the other side of the road.

THE "ECLIPSE" PORTABLE ELECTRIC BATTERY.—The following paragraph has been sent us for insertion, but as we have had no opportunity of inspecting the battery for ourselves we are not in a position to endorse the superlatives made use of:—"On Saturday last a number of gentlemen interested in electric lighting met at the offices of Mr. J. J. Walsh, White House, Telegraph-street, to witness the capabilities of this new and valuable battery, which, with its low-resistance lamp, has already been tested with the most gratifying results on the Great Western Railway and elsewhere. The lamp is suitable for domestic illumination, and is the safest and most economical electric light in existence. It is also adapted for railway signals, private carriages, omnibuses, &c. The battery will also provide motive power to drive a sewing machine, or to do any little service of the kind. Above all, the apparatus is conspicuous as a miner's safety lamp, and only weighs 4lb. or 5lb. The battery is charged with the simplest ingredients, viz., sulphuric acid and common soda, and while the battery and lamp may be obtained for a few shillings, the cost of the charge is only 2d., and it will last for 24 hours. For simplicity and cheapness it is unapproachable."

AN ELECTROMETER DESIGNED FOR INDUSTRIAL APPLICATIONS.—A note by M. J. Carpentier, in the *Comptes Rendus*, describes a form of electrometer specially designed for industrial application. We may, however, premise that one of the types of the instrument bears some resemblance to the form designed by Mr. Arthur Wright, and which has been in use for some years at the Brighton central lighting station. The advantages claimed by M. Carpentier, and which are also strikingly apparent in Mr. Wright's instrument, are extreme sensitiveness combined with a remarkable dead beat action. M. Carpentier takes a pair of metallic concentric cylinders, divided into four quadrants, which are connected oppositely by pairs in the usual manner. Between the two split cylinders hangs the "needle," which also takes the form of a pair of opposed cylinder quadrants, and is made of thin brass delicately suspended by a fine wire. In another form the cylinder quadrants are placed horizontally, and the "needle" is balanced on knife edges. The couple acting upon the needle is then opposed by the force of gravity. It is this form which resembles Wright's instrument. Quadrant cylinders, in lieu of discs, were introduced for electromoters by Dr. Edelmann, of Berlin; but M. Carpentier is, we believe, the first to employ the device of a pair of concentric cylinders. In order, however, to obtain a still more dead-beat effect M. Carpentier has carried the idea a step farther. He employs quadrants of soft iron, and places them between the poles of a strong permanent magnet. By this means the "needle" moves in a strong magnetic field, which so rapidly checks its tendency to vibrate that almost perfect aperiodicity is attained. It may be anticipated that with the increasing employment of alternating currents instruments of this kind will come into extended use.

THE EDISON-SWAN COMPANY'S MINING LAMP.—At the usual monthly meeting of the members of the Manchester Geological Society last week Mr. John S. Burrows (hon. sec.) showed a portable electric lamp for mining purposes, which has just been introduced by the Edison Electric Light Company, and which had been tried with what was described as the most satisfactory results at the Atherton Collieries. The

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lamp consists of a small strong wooden case, suspended by a strap which contains an accumulator and an incandescent lamp combined, the whole weighing about 7lb.; the cell is said to be capable of maintaining a light of 2½ candle-power for about fourteen or fifteen hours. The lamp is arranged in front of the accumulator with a concave enamelled reflector behind it, and a thick plate of glass in front to protect it. The whole apparatus is kept within a sufficiently small compass, about 7in. by 5in. by about 4in. Mr. Burrows stated that the lamp gave a better light than four Marsaut lamps, and he did not find the weight any inconvenience, as the electric lamp could be carried in any position as found convenient. Mr. J. R. Williamson (representing the Edison Company), in reply to questions, said the cost of working the lamps would be very little, as the dynamo for charging the accumulators could be driven by the colliery fan engines, and the lamps charged in the night time ready for use the next day; he did not think, however, that the lamps could be produced under 40s. each. With regard to the filaments in the lamps, they were liable to be shattered by a heavy blow on the lamp, but provision had been made to prevent the possibility of this as far as possible. The filaments were reckoned to last 500 hours before they required renewal, which was half the time allowed for lamps in ordinary use; but they had taken into consideration the rough wear and constant use in a colliery. During the discussion which followed, the general opinion was that the cost of the lamp would be a serious drawback to the general adoption throughout a colliery; but it was suggested that stations might be fitted up with them in various parts of a colliery, where they would be available in the case of an accident which had put out the men's ordinary safety lamps, whilst for exploration purposes after an explosion they would be very valuable.

Méserolé's Three-Volt Accumulators.—We mentioned recently the rumour that the electrical world would before long be astonished by the advent of a secondary battery possessing an E.M.F. of three volts per cell. We find some further information as to this important event in the *Bulletin des Société Electrique*. One naturally feels sceptical as to the validity of a claim of this character, although we should hesitate as yet to pronounce a definite opinion. The plates of this remarkable cell are now said to consist of zinc and of lead, and the solution is made up of sulphate of mercury, sulphate of zinc, and free sulphuric acid. When the battery is charged by sending a current from the lead to the zinc an amalgam of zinc and mercury is deposited upon the latter plate in the form of a thick though porus layer. The lead plate is, of course, oxidised: On discharge, according to the inventor, an E.M.F. of three volts. per cell is obtained. M. Méserolé explains the reaction as follows:—"During the charge the amalgam which is deposited upon the zinc plate carries with it nearly the whole of the liberated hydrogen, for when the cell is in good order no hydrogen is given off either in charge or discharge. In the discharge a portion of the occluded hydrogen combines directly with the excess of oxygen upon the negative plate, as in a Planté cell. But a more complex action also takes place. The deposit of zinc and mercury is re-dissolved, and the zinc displaces a part of the mercury in the sulphate which has remained in solution. The mercury in its turn displaces hydrogen from the free acid, and the hydrogen deoxidises the lead peroxide. A part of the mercury set free also probably combines with the oxygen on the negative plate. The E.M.F. will thus be equal to that developed by the zinc in replacing the mercury in the sulphate, plus that due to the action of the free acid on the liberated mercury, plus that of the combination of hydrogen with the oxygen on the negative plate." Considering, however, that the chemistry of a simple Planté cell is still a matter of hot dispute, it is too much to expect that M. Méserolé's theory of the action of his cell will meet with universal acceptance. We are more concerned at present with the practical question whether the three volts per cell can be substantiated, and, if so, whether the cell is reasonably good in other respects. The latter question is one which only actual experience of some duration can finally answer; but if the cell can bear the test of practice, we need hardly say that the invention is one of very considerable importance.

The Incandescent Gaslight Company.—Some of our readers will be interested in the following comments on the affairs of the above-named company, which we reproduce from our contemporary the *Gas World*:—"The first statutory meeting of the Incandescent Gaslight Company (Limited) was held in London on Thursday last. The chairman, Mr. H. W. Blake, gave a *resumé* of the position of affairs, but he carefully abstained from any reference to the disruption in the directorate shortly after the company was formed, and before shares had been allocated to shareholders. It is evident, however, that the chairman and his co-directors are sanguine about doing a considerable business. They have started two manufactories in London for the production of burners; they have obtained a large number of burners from Vienna, and they have placed orders in England for 30,000 more. All this looks hopeful, and we wish the company every success, because the lines on which it proceeds are those which must eventually lead to the more extensive use of gas, not necessarily of high illuminating power, for domestic and public lighting. While we say this, however, we must guard ourselves against any appearance of pronouncing unqualifiedly in favour of the Welsback light. That it is pretty goes without saying, and that it reduces the vitiation of the atmosphere to the minimum is equally true; but there are certain considerations connected with the use of this lamp which destroy, for the present at any rate, any hope that it will be universally adopted. The price, for instance, must militate against its general use, and the annual charge for maintenance is more than most people will care to pay. Toy lights are all very well in their place, but what the users of artificial light desiderate is a cheap burner, or some other economical mode of using gas. The Welsbach light costs somewhere about 15s. to begin with; a further charge of 6s. a year is insisted on to keep the mantles in order; and then, after all, the best results in the way of incandescence of the mantle are not got with ordinary pressures; and doubts are entertained regarding the power of the mantle to steadily emit the same amount of light from the beginning to the end of its existence. The fragility of the mantles was referred to at the meeting on Monday, and Mr. Mactear, one of the directors, and, if we mistake not, a co-patentee, admitted that they were delicate. He did not in the least help his case when he made reference to the incandescent filament and the glow lamp. That filament is enclosed in a globe from which the air has been exhausted; no finger need ever touch it, and if it is destroyed, then this is due to the electrical currents and not to any other physical effect. Mr. Mactear gave instances of the durability of the mantle, but these were where they were under the control of the servants of the company. The public will not, we think, have much to do with a burner which is not only expensive to begin with, but which requires so much skilled manipulation."

The Influence of Magnetism upon Chemical Reactions.—This interesting subject is receiving a good deal of

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attention at the present time, both in France and in Germany. In our last week's notes we called attention to observations of Dr. Gross, of Berlin, showing that a difference of potential is set up between plates of magnetised and unmagnetised iron immersed in dilute sulphuric acid. In the current number of the *Journal de Physique* there is an interesting paper on the same subject by M. Paul Janet. A simple theoretical explanation of this phenomenon is developed by M. Janet in the following manner: Suppose that we have a permanent magnet and a piece of soft iron, and imagine that the following cycle of operations is carried out while the magnet remains at rest:—(1) The piece of soft iron being supposed to be at an infinite distance, it is allowed to approach the magnet; let T be the work produced. (2) The soft iron is now allowed to enter into chemical combination with some other substance, sulphuric acid for example; let Q be the quantity of heat liberated. (3) The sulphate of iron thus found is removed to an infinite distance. If we neglect the magnetisation of the sulphate compared with the metallic iron, the work done upon the salt by this transfer is negligible compared with T. (4) We decompose the sulphate, so as to reconstitute sulphuric acid and metallic iron, and let Q′ be the quantity of heat absorbed. The cycle is therefore closed, and we can apply the principle of conservation of energy, so that we must have

$$T - E(Q' - Q) = 0$$

whence

$$Q' - Q = \frac{T}{E},$$

and as T is positive, $Q' > Q$, or, in other words, the heat of combination of iron is less in the magnetic field than beyond it. This explanation may be applied to the interesting experiments of M. Colardeau on the deposition of copper upon iron in the magnetic field. (See *The Electrician*, May 13th, 1887, p. 3.) The fact that the heat of combination of non-magnetised iron with sulphuric acid is greater than that of magnetised iron will tend to protect the latter from the attack of the acid in presence of the former. [It must, however, be remarked that the generalisation according to which that particular chemical reaction which evolves the most heat *always* takes place in preference to any other possible reaction is no longer admitted by many chemists, and has even been given up by M. Berthelot himself.] M. Janet concludes his paper with the remark that it results from these considerations that the E.M.F. of a cell of which iron is one of the elements should be diminished in a magnetic field, and he proposes to try to verify this conclusion by direct experiment.

GERMAN SILVER WIRE.—During the recent meeting of the American Institute of Electrical Engineers, among other incidental matter which our space will not permit us to report in full, a discussion of some interest took place on the qualities of different samples of German silver. The question arose out of a short paper by Prof. Anthony, who had found that the coils of a large resistance box had differing temperature coefficients. This particular set of resistances had been constructed some years before, by an eminent firm in this country, to a specification which required that the coils should check among themselves to ·01 per cent.; but owing to the above-named source of error it was found that the specification was only complied with for one particular temperature; almost every coil, in fact, had a distinct temperature coefficient of its own. Prof. Anthony thought that the error might have arisen in part from the wire not having all been taken from the same sample of the alloy, and also from the different degrees of strain in winding upon wires of different diameter, which would alter their molecular condition. He suggested that for fine instruments all the coils should be made of the finest wire required for the coils of highest resistance, and the lower resistances should be obtained by winding two or more of the same wires in multiple arc. Mr. Prescott said that while engaged on some experiments with Mr. E. Weston he had sought everywhere for information as to the exact proportions of German silver alloy as understood by the standard writers on electrical science. He had not, however, been able to discover a single textbook which gave the information—it was not even to be found in Matthiessen. He next made inquiries as to the practice of the various American makers, and found very little agreement amongst them. Mr. Prescott went on to say that together with Mr. Weston he had made experiments upon the alloy known as platinoid, which consists of German silver, with a little tungsten added. The resistance of this alloy is usually supposed to be higher and its temperature coefficient lower than that of German silver. But their experiments had led them to believe that the presence of tungsten had no real influence. They "made up some ordinary German silver, and put some tungsten into it, and kept on adding it up to 10 per cent., but it did not make any difference." They came eventually to the conclusion that the specific resistance of such alloy is almost directly proportionate to the amount of nickel present. By increasing the proportion of nickel and diminishing the zinc a resistance much higher than that claimed for platinoid could easily be obtained. But as the proportion of zinc was diminished the alloy lost its ductility, and the temperature coefficient decreased at the same time. With 30 per cent. of nickel the specific resistance exceeded three times that of the German silver of commerce, while the temperature coefficient was too small to be determined by the means their disposal. Mr. Wallace added that he had made large quantities of German silver and found it extremely difficult to get two samples exactly alike in their electrical properties; it depended not only on the composition of the alloy, but also on the temperature at which it was worked, and the way in which it was rolled, drawn, and annealed.

PHOTOGRAPHS OF LIGHTNING.—Last week we referred to the fact that the Council of the Meteorological Society are anxious to obtain photographs of flashes of lightning. The *Photographic News*, dealing with the conditions under which such photographs should be taken, notes the following points as important:—"First, the exact position of the camera. In many countries ordnance maps can be obtained on such a scale that a minute dot will indicate the position of the camera within a foot or two, and it will often be easy to record the position of the apparatus with far greater exactness, as, for example, when the camera is placed at a window. A thread with a plummet should be allowed to range from the optical centre (say the diaphragm in case of a doublet) to the floor, where a mark should be made. Second, the time at which the exposure was made. Third, the aspect of the camera. When the locality is exactly recorded this datum may be approximate, as there will generally be the means of exactly determining it upon the plate itself. Fourth, the equivalent focus of the lens, but the determination of this may well be left until it is found that something valuable may be deduced from the photograph. Fifth, the distance of the flash. The recording of this is a very important matter, as, when the focus of the lens is known, it will be easy to determine the actual distance between cloud and earth, and also the horizontal angle subtended to the observer at the camera. To determine the distance the observer should note as accurately as possible the time elapsing between the flash and the report, and in doing this even such a chronograph watch as may now be had for five or six pounds will be found of great service."

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 117.)

In Fig. 11 a diagram, made from experiment, is given, in which the diminution of self-induced E.M.F. towards saturation point of the armature core is clearly seen. The highest curve is drawn through points obtained by noting the E.M.F. with various exciting powers whilst running on open circuit, the lowest curve shows the E.M.F. when working with the full load of current on the armature for various exciting powers, and the intermediate curve is constructed by adding the constant Cr_a, where r_a is the resistance of the armature, to the experimental values depicted in the lowest curve; thus this intermediate diagram shows the total E.M.F. minus the counter self-induced E.M.F., and it can be easily seen that its horizontal tendency points to the same elevation as that of the highest curve in the values of which self-induction has no part.

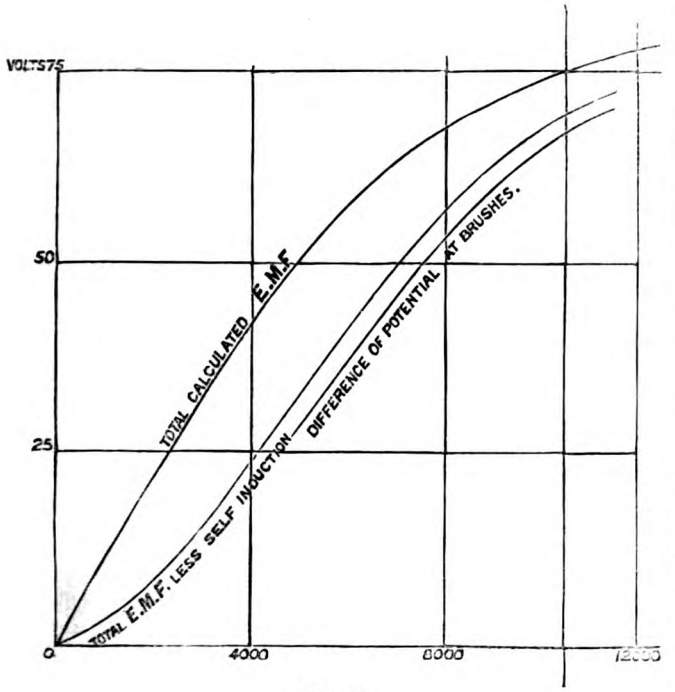

FIG. 11.

It is sometimes thought that the cross magnetisation, due to the static effect of the current in the armature, has some direct influence on the E.M.F., but this is not the case.

The effect of this cross polarity is simply to produce a distortion of the impressed field, which is driven round by it in the direction of rotation when the machine is working as a generator, and in the contrary direction when working as a motor. Fig. 12 is a diagrammatic illustration of the actions

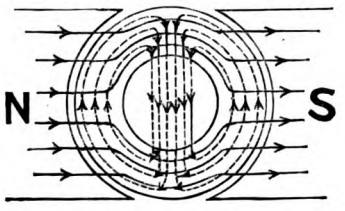

FIG. 12.

involved. Here it will be seen that the cross excitation due to the armature current would produce lines in the same direction as the impressed lines throughout one half of their path on each side of the collecting diameter, and in a contrary direction for the other half—thus the resultant effect of this excitation on the impressed field is *nil*. Also the E.M.F. induced by cutting these lines, were they actually to exist, would be *nil*, owing to the fact that they are cut in both a positive and negative sense on the same side of the collecting points.

Although it is only the E.M.F. induced by the cutting of those back lines which attend the reversal of current in coils on passing the neutral line, which is counter to the calculated E.M.F., yet the distortion of the field just mentioned has undoubtedly a prejudicial effect on the good working of the machine, and the reason of this seems to be partly because under these circumstances the collecting diameter is often brought so close to the edge of the pole shoe as to induce the lines to spring across more suddenly from the armature core than they would otherwise do. They are then cut more quickly by a very small movement of the coil than where a sufficient space intervenes. The difference of potential in a coil between the positions of collection and the angle made by one segment of the commutator with this diameter is then considerable, and sparking is therefore aggravated. Unless the segments in the commutator are extremely numerous, a large angle of distortion always points to a large amount of self-induction, so that a reduced E.M.F. often seems to be a characteristic of the distortion itself.

It was pointed out that the current reversal has to be accomplished in a definite time; this time is that required for the armature to turn through the angle covered by the surface of the brush upon the commutator, and if very short indeed, it may not be sufficient to admit of the natural fall and rise of the current; but since this must have its full strength at the close of the interval, a spark of more or less violence will pass at that moment to adjust the potential to its proper sign and value. Hence it is frequently found that thick brushes, or the device known as a slave brush, which consists of placing a second brush of similar sign, slightly in advance of the first, will materially reduce sparking in a machine of bad design. It must always be borne in mind that the effect of self-induction is to demagnetise the armature core, and therefore it is impossible to get a very high magnetic induction in a heavily wound core, having an insufficient number of parts in the commutator. This consideration should have due weight when fixing the ratio β, the value of which, as found by the curve of maximum work, should be modified if experience leads us to foresee that the self-induction would be too great. In well designed machines the E.M.F. of self-induction is seldom more than 3 per cent. to 5 per cent. of the resultant E.M.F.

Having followed the subject up to this point, the practical design of a concrete machine may be proceeded with, and since we are also seeking to make some comparison of the relative merits of the Gramme and Siemens machines as usually constructed, it will be advisable to work out the dimensions for these two, and also for the multipolar disc machine of the Gülcher or Victoria type to the same specification. The weights and sizes of those parts necessary to the electrical body of each of the three machines can then be tabulated. Such mechanical items as the bedplate, bearings, &c., could not be properly brought into this category, because they may evidently be subjected to any amount of modifications to suit the taste of the engineer.

Take then a 10-unit dynamo required to give 100 volts at the terminals, and 100 amperes, at speed of 1,000 revolutions per minute. We are not able to say at once what the electrical efficiency of such a machine will be, but we know by experience within one or two per cent., and shall be tolerably safe in assuming it at 90 per cent. In the same way it is necessary to assume the counter E.M.F. of self-induction. This we may take as 5 per cent. of the resultant E.M.F. The total upon which the calculation must be based will thus be

$$E = \frac{1000}{9} + \frac{1000}{9 \times 20} = 117 \text{ volts.}$$

For the first example we will take a cylinder Gramme ring, such as the Crompton, Kapp, Goolden and Trotter, &c., &c. machines, in which, referring to Fig. 6, No. 22, Vol. XVIII., the ratios will be fixed as follows: —

$q = 2$	$M = 20$
$p = \cdot5$	$\gamma = \cdot8$
$\beta = \cdot1$	$\mu = \cdot7$
$\rho = \cdot9$	

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With respect to μ it should be remarked that, as its value depends upon the size of wire which is used, there is no certainty in fixing it to start with, but after having obtained a value to suit a particular machine, it is easy to approximate very nearly to the correct value, for it was shown that in an armature wound with a constant number of turns $C \propto R^{\frac{3}{2}}$, whence it is clear that the current density $D \propto R^{-\frac{1}{2}}$, but $EC \propto R^{\frac{5}{2}}$ with constant peripheral velocity; $\therefore D \propto EC^{-\frac{1}{5}}$.

The sectional area A is now determinant, and μ can thus be approximated. The core in such a machine as the one we are taking is built up with thin iron washers; the value for γ is therefore well within the mark at ·8.

From equation (4) we get

$$R = 3{\cdot}6 \times 1{\cdot}274 = 4{\cdot}59\text{in., say } 4\tfrac{5}{8}\text{in.,}$$

$$\text{also } N = \frac{E{\cdot}10^6}{2\,M\,p\,q\,\gamma\,n\,R^2} = 174$$

$$A = \frac{2\,\pi\,\mu^2\,R^2\,\beta\,(1-p-\beta)}{N} = {\cdot}0149 \text{ sq. in.}$$

The depth of copper on the inner winding $\mu\,\beta\,R = {\cdot}32$in., and this must now be divided into a suitable number of layers. If this number is made too small the cross-section A will be awkwardly divided, so as to make the depth of the strip greater than the width. This would introduce a serious difficulty in the winding. If, on the other hand, it is too large the parts in the commutator will become too few. In the present instance the happy medium will be struck by making three layers on the inside. The thickness of the strip will then be $\frac{·32}{3} =$, say, ·11in., and the width $\frac{·0149}{·11} =$, say, ·135in.

It is now possible to check the value assumed for μ, and we find $\frac{·135}{·135+·05} = ·73$, which is near enough to the estimated value. Should the check show a more serious discrepancy, we have from eq. (5) $R \propto \left(\frac{1}{\mu}\right)^{\frac{2}{7}}$, other things being equal; the value of R can then be altered in the ratio of $\left(\frac{\mu}{\mu_1}\right)^{\frac{2}{7}}$ where μ_1 is the corrected value.

In the same way N is altered in the ratio $\left(\frac{R}{R_1}\right)^2$ and A in the ratio $\frac{R_1^2\,N}{R^2\,N_1}$; the resulting value for μ will then be found to lie on the other side of the true value, so that all the quantities may be fixed between the two sets of values.

It is necessary that the number of turns N, after having been divided by the number of layers l on the inside winding, should still be a multiple of the number of poles P. The figure 174, which was obtained for N, happens to fulfil these conditions, but had it not done so it would have had to be altered, and the area of core section slightly modified to satisfy the equation

$$E = 2\,M\alpha\,.\,N\,.\,n\,.\,10^{-6}.$$

In the case in point, however, N constitutes the proper multiple, and the number of parts in the commutator are found to be

$$S = \frac{174}{3} = 58.$$

It will be as well in making calculations such as these to check the results at this point by the equation for the E.M.F. given above, only substituting $p\,q\,\gamma\,R^2$ for a, thus

$$(2 \times 20 \times ·5 \times 2 \times ·8 \times 21) \times 174 \times 1000 \times 10^{-6} = 116{\cdot}93,$$

which is correct.

Before leaving the design of the armature it is necessary to decide upon the disposal of the winding on the outside of the ring.

Whenever it is possible, it is always best to make the winding shallow on the outside so that the length of the air gap δ may be small. In calculating the number of wires which would lie around the periphery, however, it is not necessary to allow so much as ·05in. for insulation, because that space also contains an allowance for the driving arms of the armature; moreover, the wires can be packed more closely on the top than at the inside, where the manual operations are more difficult. ·03in. will therefore be quite enough to allow both for insulation (which should not exceed ·02in.), and also for a certain amount of latitude which is necessary to avoid jamming of the wires.

The perimeter of the ring in question is $9{\cdot}25\pi$, which, divided by $·135 + ·03 = 176$; thus the 174 wires will go on with ease in one layer. The practical winding of an armature with three layers inside and one layer outside is not a matter of any real difficulty, and when men are accustomed to what is termed "riding" they soon pick up any kind of winding.

(To be continued.)

TELEPHONIC INVESTIGATIONS.*

BY NELSON K. CHERRILL.

At the meeting of the Society of Telegraph-Engineers on the 24th February last the President asked that any members who were desirous of speaking should make their remarks as concisely as possible, the time for discussion being limited. As a stranger to the meetings of the society I did not like, under these circumstances, to occupy the time of the meeting with the following remarks, but having since committed them to paper, I am sending them in case you think them worthy of separate publication:—

If we form a loose contact between two pieces of carbon the resistance of the arrangement is lessened by a pressure which tends to tighten the contact, and is increased by a removal of that pressure. I believe this fact has been known for a long time. In 1878 Prof. Hughes showed by his discovery of the microphone that a loose contact placed in a state of vibration would modify a current passing through it at the time in a manner proportional to the vibrations, and I think I am right in saying that the conclusion was immediately arrived at that the "microphonic action" was due to variation in pressure.

That this is the commonly received view is beyond question; that it is so is shown by the design of all the instruments in common use, and by the theoretical explanations offered by Prof. Silvanus Thompson. It is this view which I venture to combat, and I trust to be able to show that, although variation in pressure undoubtedly produces variation in the conductivity of the joint, this variation is independent of, and has nothing to do with, the telephonic action by which speech, music, &c., can be electrically conveyed.

The difficulty which presents itself when we consider telephonic action as arising from variations in pressure is that on this assumption we must admit that pressure must be in some instances *both increased* and *diminished* at the *same time*. Let me be quite explicit. Let A B (Fig. 1) represent the diaphragm

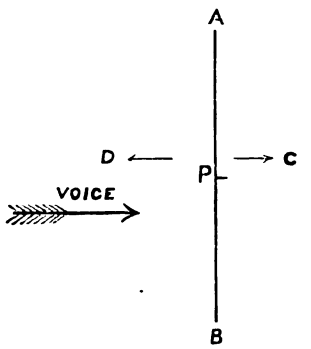

FIG. 1.

of a Blake transmitter. There is a platinum point shown at P. The voice comes from the direction indicated by the arrow.

* A further note on the recent discussion at the Society of Telegraph Engineers.

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Now the *implied* explanation of the pressure theorists is that the waves of sound are "collected" by the diaphragm, and that the point P moves alternately in the direction C and D, increasing pressure as it moves towards C, and diminishing it as it moves towards D, the current being, of course, varied accordingly. This explanation is very simple when only a simple sound is given, such as the note of a tuning fork on the word "ah," &c.; but now suppose *two* sounds are given, the one being the octave of the two.

To produce the octave of any note the vibrations must be evidently twice as quick as those in the note itself; there must therefore be on the pressure theory twice as many increases of pressure in the one case as there are in the other. That is to say, the point P must, to produce the lower note, be at its extreme limit in the direction D at the same moment that to produce the higher note it is at its greatest distance in the direction C. In other words, the point P must be in two places at the same time, which is absurd; or, what is equally absurd, on the pressure theory, the current must to produce a note and its octave be both increased and diminished at the same time.

I know the common explanation of this and similar difficulties is that the movement of the point P is the resultant movement of all the sound waves on the diaphragm. So it no doubt is, but the "explanation" to me *explains* nothing.

If the current as modified by the transmitter is simply the "resultant" corresponding to the various pressures caused by the vibration of the diaphragm, how is the receiving instrument to know how to divide up the current so as to produce a like result at its end of the line? The idea seems to me much the same as if one should break up a column of type and send it in a box to a correspondent at a distant station. How is he to know how to recombine the letters so as to reproduce the ideas originally expressed by them?

Tyndall in his book on sound tells us that a resultant *tone* is a tone which corresponds to a rate of vibration equal to the difference of the rates of vibration of two primary tones, and he goes on to show that the resultant tone is always lower than either of the two primaries; hence hearing a note and its octave in the telephone cannot be explained by any suggestion that the tones heard are "resultant tones."

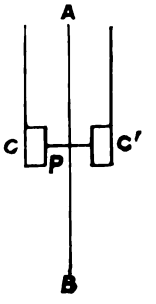

Fig. 2.

It is sometimes suggested that as with a stretched string—as in a violin—not only the fundamental note is heard, but also many harmonica and over tones, with only one constant movement of excitation to keep up the vibration, so, somehow or another, one set of movements in the diaphragm will cause different tones to be heard in the receiver; but I cannot see that the cases are parallel in any degree. In support of the idea that pressure variation is *not* the cause of telephonic action, I made an experiment which is very interesting, if not quite conclusive. I removed the little spring carrying the platinum point from a Blake transmitter, and substituted for it a piece of platinum wire, which passes straight through the diaphragm, and is soldered to it; the wire terminates in a point at each end, about a quarter of an inch from the diaphragm. I then hung in front of the diaphragm a second block of carbon, making the pressure as nearly equal to the original block as I could. The arrangement is represented in Fig. 2, where C C' are the two carbon blocks, A B the diaphragm, and P the platinum wire between the two blocks, soldered to the diaphragm. I led the current from C through P to C', and thence to the transformer.

The object in this arrangement was to make the diaphragm vibrate between the two carbon blocks, so that if we were working by pressure the increased pressure on C' should occur at the same moment as a diminished pressure on C, and *vice versâ*. I thought, if the pressure theory were correct, such an arrangement should *not* act telephonically, as the pressure and diminution of pressure should neutralise each other. To avoid any suspicion of C being *driven on* to the diaphragm by the same air waves that drove the diaphragm itself on to C', I *conveyed* the vibrations to the diaphragm by means of a wire which pressed against it at one end, and against the case of a small American clock at the other. With this arrangement I found I could detect no difference in the clearness with which the sounds were conveyed, whether the current was led from the diaphragm to C', as in the ordinary way, or from C to C' as described, and I thence conclude that as the pressures and diminutions of pressure between C and C' did not *neutralise* the currents they (the pressures) could not have been the immediate governing conditions of the current strengths. I am aware that this experiment is open to the criticism that to amount to a demonstration it would be necessary to show that the conditions on each side of the diaphragm are exactly alike in all points.

In making the actual experiment I put a contact key between C and P in such a manner that the one microphone could be short-circuited out of action without otherwise disturbing the arrangement. The sound in the receiver was *louder* when only one microphonic contact was at work, as would be expected, because so much less resistance would then be offered to the battery current (one cell of bichromate); but the sounds were equally *distinct* with the two contacts as with one. The scraping of the wheels, the clang of the spring, and all the host of sounds which go to make up the tick of a clock, were reproduced with equal clearness in either case.

There is another point, however, in favour of the view I am taking, which is, that with some at least of the commercial telephones, if the pressure theory is correct, the sibilant sounds ought to neutralise themselves. Mr. Preece tells us that the sibilant sounds go up to 4,000 or 5,000 vibrations in a second. The longest of these gives a wave length of ·275ft., or say about 3⅜in. The half of the wave length is evidently the distance between greatest and least pressure, so that any telephone transmitter having many microphonic contacts, may very well have some of them 1¾ distant from each other, and in such a case a sibilant tone of the above mentioned velocity ought to neutralise itself if it come in the direction of the line joining the two contacts. Practically, any transmitter of many contacts ought, on the pressure theory, to cause interferences, more or less, with the higher notes, according to the distances of the contacts from one another and the direction of the sound waves. I have not heard of the case of any such interferences having been actually observed, though Prof. Silvanus Thompson seemed anxious to provide against them when he stated in describing his transmitter of 108 microphones that "the impulses do not, of course, pass down the steel rod absolutely instantaneously, but the retardation of phase of even the shrillest of vocal sounds is quite negligibly small."

But is not the instrument devised by Prof. Silvanus Thompson himself, the "Valve," or ball transmitter, one of the best means of refuting the doctrine that telephonic action depends on variation of pressure? In describing the instrument Prof. Thompson says:—"The loudness of the valve telephone is limited by the fact that it is not expedient to work with more than three contact points, the limit being a natural geometrical one," by which, I take it, he means that a spherical surface will rest naturally with equal pressure on three points, and that it is extremely difficult, if not impossible, to make it rest on more points with equal pressure on all of them. It is obvious that the pressure on the three points will be, roughly speaking, equal when the instrument is at *rest*, but as soon as spoken into the case becomes widely different. Prof. Thompson, in his explanation, says the ball or valve "*rides* on the vibrations of the air waves." That may be so, but it can hardly be pretended that the valve whilst so "riding on the vibrations" maintains an equality of pressure on all its supporting points! It would appear that the very idea of "riding on a vibration" involves

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lateral as well as vertical movement, and, if so, the pressures in the supporting point would be constantly *varying*; and, moreover, the ball would be approaching some of the contacts at the same time that it was receding from others of them. If, then, microphonic action is due to *pressure*, the valve telephone as described would produce sometimes one, sometimes two, and sometimes three distinct and separate interpretations of the same note, depending on the phase of vibration which the ball happened to occupy with regard to its three supports. As this is not the case, I think we may again conclude that telephonic action does *not* depend on variation in pressure, inasmuch as with the valve telephone vibrations of the same values are transmitted through contacts of obviously various pressures.

The very curious and interesting observation given by Mr. Stroh, in which he found the *timbre* of the sound transmitted by a microphone was altered by the adjustment, admits, I think, of another explanation than that put upon it by that gentleman. He finds the first contact of the two carbons is generally followed by a burning, which is, no doubt, the removal of the rough excrescences of the carbons by the heat developed in them by the current. If after this burning it happens that the carbons touch over a sufficiently large area, the current will pass silently and without any undue development of heat; but it is also easy to see that if the carbons happen to meet, say on the top of a little nodule, this may get very hot in carrying the current (though perhaps not hot enough to harm); the heat produced may by longitudinal expansion throw off the other carbon, if, as is explained by Mr. Stroh, the adjustment is very delicate, and this action would produce a rocking motion in the same sort of way as in Tyndall's explanation of the Trevelyan rocker, which would continue till either the adjustment of the spring was altered or until the constant hammering enlarged the surface area of contact to that point at which the current would pass without giving heat enough to produce the effect. If this line of reasoning be correct it is obvious that the area over which actual contact is made in a microphone may be a very variable amount, and it is further obvious that with a given pressure a variation in the area of the contact will give a corresponding variation in the actual current sent through the instrument. The sounds transmitted by the microphone are heard *through the current*, and whether the current is large or small (comparatively) the microphone differentiates all the parts of the sound, but, according to some experiments I have made, the *timbre* of the sound heard in the receiver varies with the amount of current passing, and hence the explanation of the phenomenon alluded to by Mr. Stroh.

(To be continued.)

MICHAEL FARADAY.

At the instigation of Count Rumford the Royal Institution was founded towards the close of the last century. From its inception to the present time this institution has been regarded as one of the greatest centres of English science. Inseparably connected with it are the names of Young, Davy, and Faraday —the greatest of whom, in our estimation, was Faraday.

While the name of Young will ever be connected with physical research in relation to light, so that of Faraday will be connected with his researches into the hidden mysteries of electricity. Half a century ago Faraday was in the hey-day of his activity and success, and it seems, therefore, but just that we should recognise in him the leader of science most intimately connected with the accession to the Throne of Queen Victoria, whose Jubilee has just been celebrated.

It is with these feelings that we present to our readers the accompanying portrait of the late Prof. Faraday, and without in any way desiring to emulate his biographers, we may be allowed at the same time to give a slight *resumé* of the salient incidents in his career.

Amongst the philosophers of Europe who have risen into the first rank of eminence by sheer force of intellectual energy and personal merit alone, Dr. Faraday occupied the foremost position. Without "patronage" or "friends" he steadily progressed, from a comparatively humble origin, to the position of the first experimentalist in this country, and his discoveries and theories have not only laid new foundations in science, but he lived to see their application to the purposes of daily life so extended that, from the lowest to the highest, throughout the civilised world man has been benefited by his researches.

Dr. Faraday was born at Newington, Surrey, on the 22nd Sept., 1791, and his early education was limited to the ordinary routine of private schools. At the age of 13 he was apprenticed to a bookbinder, but he speedily gave evidence of a taste for scientific matters, and his earliest experiments in electricity were the germ of pursuits that have resulted in discoveries connected with that science through which its theories have been completely revolutionised, whilst its applications in telegraphy, electro-plating, and electric lighting, have been of invaluable benefit to commerce and society in general.

The young student had the good fortune to hear some lectures, delivered by Sir Humphrey Davy at the Royal Institution in Albemarle-street, in February, March, and April, 1812. He took notes, and, amplifying them with remarks, drawings, &c., sent them to Sir Humphrey, who kindly replied to the letter, and early in the following year offered him the situation of chemical assistant under himself and Dr. Brande. Faraday shortly afterwards entered on the duties of his new position, and went to reside at the institution, where he subsequently spent, with but trifling exceptions, the greater portion of his life. Shortly after entering upon his engagement he travelled as assistant with Sir Humphrey Davy in various parts of the Continent, and in April, 1815, returned to the Royal Institution.

It would be impossible in our limited space to detail the various discoveries and researches which occupied Dr. Faraday during half a century. The whole subject of electricity and magnetism, which had hitherto been entirely in the empiracal stage, underwent systematic investigation by Faraday, and the secrets of nature gave themselves up to his researches, with results which are made known to the world in the various series of "Experimental Researches" published in the *Philosophical Transactions* of the Royal Society. "Electric Induction," "Magneto-Electricity," "Electro-Chemistry," "Dia-Magnetism," &c., successively formed the subjects of extension of the series. With respect to these we cannot refrain from remarking that they form admirable models and lessons to the tyro in science, not only in respect to the subjects on which they treat, but also on account of the rigid Baconian method—of experimenting *first* and theorising afterwards—which is followed throughout. In no part is imagination allowed to override scientific induction. If a theory be offered, the steps which led to its promulgation, and the reasons proposed for its adoption, are laid out with almost Euclidian precision. Had we more instances of such cautious, painstaking methods amongst philosophers of the present day, science would have less frequent reason to mourn the obloquy that too frequently follows the explosion of fantastical theories, based on limited knowledge, which at times are hastily emitted by less careful individuals than the one who is the subject of this memoir.

In connection with chemistry Dr. Faraday took the mantle of his great predecessor, Davy, and in developing the relations of electricity and chemistry, especially in regard to the laws of electrolytic action, he not only fully elucidated that of which Davy was the originator, but carried on these investigations to a much further extent. His experiments in another branch of chemical science—the condensation of gases—are of deep interest, and incidentally threw much light on the laws of latent and specific heat. In optics he first pointed out the relations of a polarised ray of light in regard to magnetism; the discovery of "heavy glass" in 1829 afforded him a material which was of the utmost value in the study of those phenomena. The general result of his discoveries in this and allied subjects leads to the belief that heat, light, electricity, and magnetism may be regarded as the development of *one* force, in a special form, rather than as individual forces acting on matter independent of each other.

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From the year 1827 up to the period when failing health and increasing age caused the withdrawal of Dr. Faraday from active public engagements, he regularly delivered lectures at the Royal Institution. In 1833 he was chosen Fullerian Professor of Chemistry by the founder of the chair, the intention being expressed that he should continue to hold the position as long as he remained connected with the institution, without being required to deliver lectures, and solely in consideration of the value of his researches to the cause of science. His lectures to young people, given during the Christmas vacation, were distinguished by simplicity of style, just as his scientific researches are characterised by depth and philosophical exactness, and in their published form have been read and admired by a large class of readers.

That honours were largely conferred on Dr. Faraday would be naturally expected. In 1823 he was elected a corresponding member of the Academy of Sciences of France; in 1825 he was chosen a Fellow of the Royal Society, and in 1832 the University of Oxford conferred on him the degree of Doctor of Civil Laws. He was also one of the eight Foreign Associates of the Imperial Academy of Sciences of France; a Commander of the Legion of Honour; and a Knight of the Prussian Order of Merit. For his important discoveries Lord Melbourne's Government assigned him an annuity of £300 in 1835. He was a member of numerous scientific societies of this country, the Continent, and America.

His life, until he entirely gave up scientific pursuits, was one of constant devotion to experimental philosophy. But at last the strength of mind of this great philosopher became weakened. In the retirement of his quiet residence at Hampton Court, placed at his disposal by Her Majesty, he ended his days, almost excluded from the world. His death took place on Sunday, August 25, 1867, and his remains were interred at Highgate Cemetery the succeeding Friday, followed by a few personal friends who had long known and loved him.

A NEW METHOD OF MAINTAINING THE VIBRATION OF A PENDULUM.

A recent number of the *Comptes Rendus* contains a note by M. J. Carpentier describing a method of maintaining the vibrations of a pendulum by means of electricity, which differs from previous devices of the same character, in that the impulse given to the pendulum at each vibration is independent of the strength of the current employed, and that the pendulum itself is entirely free, save at the point of suspension. The vibrations are maintained not by direct impulsion but by a slight horizontal displacement of the point of suspension in alternate directions.

This, as M. Carpentier observes, is the method which we naturally adopt in order to maintain the amplitude of swing of a heavy body suspended from a cord held in the hand. The required movement of the point of suspension is effected by means of a polarised relay through the coils of which the current is periodically reversed by the action of the pendulum, in a manner which will presently be explained. The armature of the relay oscillates between two stops whose distance apart is capable of fine adjustment.

It is clear, therefore, that the impulse is independent of the strength of the current in the relay provided that the armature is brought up to the stop on either side. The reversal of the current is effected by means of a small magnet carried by the bob of the pendulum, and which as it passes underneath the point of suspension is brought close to a soft iron armature, which has the form of an arc of a circle described about the point of suspension. This armature is pivoted at its centre, and thus executes vibrations synchronously with those of the pendulum. These vibrations are adjusted to a very narrow range, but are sufficient to close the contacts of a commutator which reverses the current at each semi-vibration of the pendulum.

The beauty and ingenuity of this device will readily be appreciated.

ELECTRIC ILLUMINATIONS FOR THE JUBILEE.

(*Continued from last week.*)

The Electrical Power Storage Company were practically working day and night for some weeks, in order to cope with the demands made upon their resources for supplying temporary installations of the electric light during the Jubilee celebration. A great deal of their business consisted in providing illuminations for balls, receptions, &c., amongst others being those for H.R.H. the Prince of Wales, the Duke of Westminster, the Duke of Leeds, the Earl of Rosebery, Lady Henniker, &c. Of the outdoor installations which the company put up may be mentioned those for Downshire House, Belgrave-square, where the lights were arranged in festoons and rows over the portico, creating a very pretty effect, and for Queen Anne's Restaurant, Cheapside, where the outline of the front of the building was brought into strong relief by a tasteful arrangement of incandescent lamps An unambitious but, nevertheless, exceedingly effective installation was that over the main doorway of the Bank of New Zealand, which came in for a great deal of public admiration. This was a device consisting of an electrically lighted transparency, worked by the bank's own permanent installation. To this company is also due the credit for the artistic illumination of the residence of Viscount de Stern, in Great Stanhope-street, W., with incandescent lamps in tinted shades, as well as the Magistrates' Club, 88, St. James's-street, S.W., where the lamps were cleverly placed, so as to set off to the greatest advantage the floral decorations of the building. Numerous orders for lighting rows of houses, gardens, &c., in the the West End of London, came to hand too late for execution.

The students of the School of Electrical Engineering and Submarine Telegraphy, Prince's-street, Hanover-square, set up a device in glow lamps forming the letters "V. R." on a background of white cotton wool, which produced a beautiful effect.

The Institution of Civil Engineers in Great George-street, Westminster, gave an electric light display worthy of the occasion. This was carried out by the Anglo-American Brush Company, and was one of the most conspicuous installations in the vicinity of Westminster. It consisted of 500 glow lamps, arranged two in series, each of 10 candle-power, and aggregating 18,550 watts, forming the device, "1837—1887—Her Most Gracious Majesty the Queen." The panels at the top of the building were also illuminated with another device, showing the name of the Institution, the whole being exceedingly effective. In connection with this installation it could not fail to be remarked how much superior to other illuminants is the electric light, especially for outdoor illumination, for while the effects of other devices in the neighbourhood were at times painfully marred by gusts of wind, that at the Institution of Civil Engineers—and, indeed, wherever electricity was used as the lighting medium—remained uniformly bright and steady.

Next to Regent-street and Piccadilly, Old and New Bond streets were, perhaps, most conspicuous in the West End for the variety and extent of their illuminations and other decorations, and as might naturally be imagined the Grosvenor Gallery occupied in this respect a prominent position. The front of the building was brilliantly lit up by electric incandescent lamps; whilst stretching from one side of the street to the other there were several rows of lights, from which was suspended a bust of Her Majesty, surrounded by numerous lamps of various tints. The company also contracted for a large number of installations over the extensive area which they ordinarily supply, notably, in Bruton-street and Regent-street. Like most other companies, the demands made upon them were greatly in excess of the capacity of their plant.

In the Strand and Fleet-street there was also a good deal of electric light illumination. But by far the most imposing of the installations to be seen there were those at the *Daily News* office and the Gaiety Theatre. For the former the Fyfe Main Electric and Construction Company were responsible. The windows of the building facing both Bouverie-street and Fleet-street were gaily decorated with flowers and evergreens, in the centre of which there was fixed a powerful arc light, the outlines of the windows being followed by variously tinted incandescent lamps.

That at the Gaiety Theatre was supplied from Messrs. Spiers and Pond's permanent plant, and consisted of a pretty device in the shape of a crown of variously tinted incandescent lamps surmounting the glass-covered way at the main entrance to the theatre. For design and richness of colour nothing could have been better, a a fact to which the crowds of people who passed to and fro both on Tuesday and Wednesday night frequently testified by vociferous cheers.

Our enumeration might, in fact, be indefinitely extended, for in all probability there was scarcely a single installation of electric light in all London but what contributed its share to the general display of public rejoicing.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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THE JUBILEE.

Readers of this journal, we are glad to know, are scattered all the world over; but, being familiar with the English language, they will need no explanation or apology for our choice of a subject to write about to day. In point of fact it is not so much a deliberate mental choice as an involuntary physical necessity that compels us to say something of the JUBILEE. The air of the British Metropolis has been full of it for months past; at the close of the present week our ears are still ringing with the echoes of Tuesday's festival, and our eyes still aching with the reflections of its splendour. On a quite commensurate, if not on so magnificent a scale, these tokens of rejoicing have been repeated throughout the whole country, and the telegraph has already told us that our brothers in far-off lands have enthusiastically done their part. Much less than fifty years ago—nay, less than twenty—it would have taken as many days as it now takes minutes to bring this gratifying news home to us, and the beacons which were set burning on every hilltop would have been a stern practical necessity half a century ago, instead of a mere pleasant revival as they were last Tuesday night. In the year of Jubilee as originally conceived the acquisitions of fifty years were returned to their former owners amidst the blowing of many trumpets. If in this year of grace we were required to undo all that we have done, and to give back the possessions we have wrung from nature since 1837—to say nothing of those we have appropriated in more questionable fashion—the result would be satisfactory to nobody, and the trumpeters hard to find.

In these days we are far more disposed to trumpet every addition to our store of material wealth; and when a jubilee happens to occur in the reign of a sovereign, as it has just now, one of our ways of showing jubilation is to reckon up the gains afresh and proclaim them with a very loud flourish indeed. After all, this is the most sensible plan, and, in fact, the only feasible one, the other being a pious aspiration which it is nowhere recorded was ever put into practice. We need not discuss it, therefore; but, for all that, it may very well serve to remind us of a certain moral duty which we might easily discharge on occasions like the present—the duty, namely, of acknowledging our obligations to men and things that have contributed to make the period of Jubilee one to look back upon with pride and congratulation. Our own humble contribution to the discharge of this duty—the one that seems to concern us nearest—is presented with the present number of *The Electrician*. FARADAY was a man whose memory we can recall with unfeigned admiration and reverence, and whose services to the electrical activities of the past fifty years we are bound to recognise with feelings of wonder and gratitude. We do not believe that we could have made a more appropriate choice among the scientific celebrities who have added lustre to Her Majesty's reign, though we may confess the inadequacy of the offering. Still, it is something, and our readers, we are sure, will accept it as a Jubilee memorial of peculiar interest to them. FARADAY's work will never die; his picture may serve to keep us mindful of the man who did the work.

It was the last thing in our thoughts when striking off this portrait of FARADAY to make any comments of a sort not jubilant, but it is difficult to repress all mention of the singular fact that, down to the moment of our going to press, there has been no public recognition of the part which science has played in the achievements of the half century, except the science of warfare, which, being aggressive and combative, never fails of its reward. Among the long list of names that have been honoured under advice by the Sovereign Lady of the land with promotions or distinctions there occurs none associated nearly or remotely with either Letters or Science or Art. We say singular, because we are not disposed to call it by a more disagreeable epithet. It may be an oversight, or it may be the result of just that inexplicable state of mind in high quarters which at first allotted the Royal Society exactly one ticket for the Jubilee service at Westminster Abbey. This was really very odd in more senses than one; and we cannot pretend to explain it except by a supposition which would be anything but flattering to the other recipients of royal favours. Perhaps it is assumed that the votaries of the arts and sciences pursue their vocation without desire or expectation of reward. Let us hope that they do, for then, verily, they will not be disappointed. It is a drawback to the aristocratic institutions of this country that no man can get a handle to his name who has not first put money into his pocket. This is perhaps as it should be, for a gilt handle on a poor vessel would only make it look (and feel) the poorer. But where poverty is a bar to military distinction, promotion always remedies the defect; and we see no reason why the same practice should not prevail for the arts of peace. At all events, we could invite them to share in a Jubilee festival, and even scatter a few C.B.'s, without much risk of discredit among the distinguished and deserving poor.

Despite of this seeming avoidance of public recognition, we are glad to observe that the Jubilee of the Telegraph will not be allowed to pass over without a fitting celebration. The Society of Telegraph-Engineers and Electricians, it appears, does not take up the matter in its corporate capacity; but we

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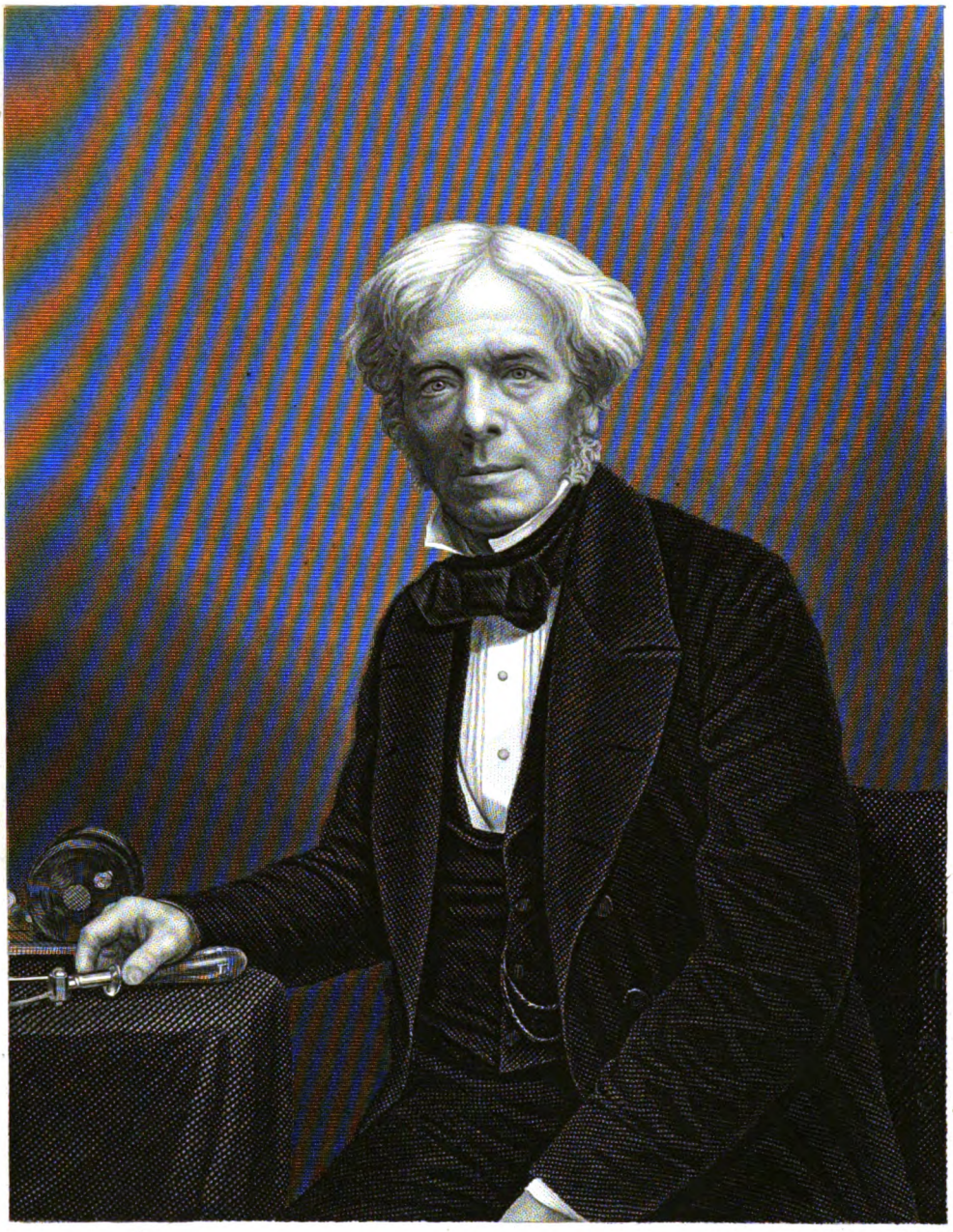

MICHAEL FARADAY, ESQ. F.R.S. D.C.L.

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learn that a representative gathering will be brought together some time next month to commemorate the first electric telegraph in a manner most agreeable to the tastes and inclinations of Englishmen, who always love to dine before testifying to their good humour. As regards the Electric Light, it has had its gala opportunity during these jubilant illuminations, and has come out of the ordeal, we must say, with flying colours. *The Times*, with its usual infelicity, has remarked upon the inartistic character of the new illuminant, apparently because some indiscreet persons used it in a theatrical fashion for casting beams of light across the housetops, and so marring the general grouping. It might as well complain of the domestic firegrate because the bonfires were extremely vast and lurid. From what we saw of places where the electric light was used we can confidently assert that for brilliancy of effect and colouring the oil lamps and gas lamps were nowhere in the competition. Wherever the electric current was employed, there unmistakably the colours were most beautiful and the light the most vivid.

THE JUBILEE OF THE TELEGRAPH.

We are glad to be able to announce that strong efforts are being made, and so far with great success, to suitably recognise the "Jubilee of the Telegraph." The normal English method of keeping anniversaries is to be followed on this occasion. It is proposed, therefore, to have a dinner on Wednesday, July 27th, when the POSTMASTER-GENERAL will take the chair, as representing the telegraphic interests of the Empire, and we understand that Mr. JOHN PENDER will be one of the principal guests, as representing the cable interest. United action from all branches of the profession, and co-operation from those interested in the theory of electricity as well as those more directly interested in its practical application, should make this a red letter day in the annals of electrical science. Further details will be given as soon as possible; meanwhile we trust that all those engaged in electrical matters will lend their aid to make this meeting a grand success. In addition, we may state that in all probability the annual *conversazione* given by the President of the Society of Telegraph-Engineers will be held on Monday, July 25th, so that the week may be looked upon as one celebrating the inauguration of the most wonderful of all the developments of modern science.

CORRESPONDENCE.

NOMENCLATURE—MAGNETIC RESISTANCE, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As there is at the present time at least a possibility of the various words I have proposed coming into general use, I take the opportunity of making a few casual remarks upon the subject supplementary to those of 1885 and since. First, I observe on p. 114 (June 17) that you mention that I disapprove of "magnetic resistance." This is only a part of the fact. To illustrate this, I may say that were I investigating the theory of the dynamo, I think I should make use of the term myself, provisionally. What is really my objection is to its permanent use. There must always be a certain latitude allowed to investigators who do not find words ready to meet their wants. Were it an isolated question, there would be little difficulty in finding a perfectly unobjectionable word; but it is not an isolated question. My aim has been to make a scheme which shall be at once theoretically defensible and yet thoroughly practical. Bearing this in mind, I prefer to leave a blank in the place of "magnetic resistance" at present.

To illustrate the difficulties connected with nomenclature I may mention that last summer I was extremely in want of a term which should be an extension of impedance. The impedance of a circuit at a given frequency (under stated external conditions) is quite definite (with occasional departures due to want of proportionality between forces and fluxes), if it be a simple circuit, or reducible to a simple circuit, so that the strength of a current does not vary in different parts. But when it does we can certainly only legitimately apply the term impedance at the seat of the impressed force, if at a single spot; or else, if it be wholly localised in a part of the main circuit in which the current does not vary, then the term impedance is applicable. Now, I used impedance in an extended sense, but expressly stated that it was only done provisionally. I have since found a far better way of expressing results, viz., in terms of "attenuation" and "distortion," both very important things. The idea of attenuation, expressed in a more roundabout manner in terms such as diminution of amplitude, and so forth, is nothing new; the *word* "attenuation" I found Lord Rayleigh use, and at once adopted it myself as the very thing I wanted. "Distortion," on the other hand, I chose myself as preferable to mutilation and similar words. Its meaning is obvious. Make current variations in a certain way at one place. If the current variations at another place are similar, no matter how much attenuated they may be, there is no distortion. The extremest kind of distortion is to be found on Atlantic cables. Drawn on the same scale, there is little resemblance between the curves at one end and at the other. Telephony would be obviously impossible even were the frequency allowable to be sufficiently great, which is of course out of the question under present conditions. But only make the distortion reasonably small at a sufficiently great frequency and telephony is at once possible, provided the attenuation be not of unreasonable amount. (Frequency is Lord Rayleigh's word for "pitch," number of waves per second.)

Magnetic resistance again. A certain person once declared that $E = RC$ to express Ohm's law was nonsense; it must be $C = E/R$. This eminent scienticulist could not see the force of Maxwell's argument that electricity could not be a form of energy, because it was only one of the factors of energy. Now, however, through the development of the electric light rendering energy a marketable commodity through electric agency, there is not the least fear of converts being made to these views. So we may return to $E = RC$, or $C = KE$, if K be the conductance. One is just as good as the other, theoretically, and just as meaningful. Which to use (including the ideas) is purely a matter of convenience in the particular application that is in question. As a general rule, resistances are most useful, because we usually deal with wires *in sequence*. But if they be in parallel, conductances are the proper things to use. With condensers, on the other hand, permittances are most useful; should, however, we join in sequence, then elastances are the proper things. In theoretical investigations disconnected from special applications, the unit-volume properties conductivity, inductivity, and permittivity, are generally much more useful than their reciprocals, resistivity, (?), and elastivity. Now in late years there has been some development of practical applications in connection with the flux magnetic induction; in theory inductivity would be the most convenient basis; but several practical men find that the reciprocal ideas, say provisionally "magnetic resistivity" and "magnetic resistance," are most useful. I think their choice has been a wise one, whilst at the same time I recognise the difficulties they have to contend with, with "magnetic leakage," and so forth. It is for the practical men to find practical ways of getting a round peg to fit a square hole. They know best what they want, and whether empirical formulæ will not suit them better than more elaborate empiricism, which could be perhaps scientifically better defended. For it is clear that, beyond the region of proportionality of force to flux, the science of magnetic induction must continue very empirical for some time to come. I do not think the time has yet arrived for laying down the law by conventions or committees in this matter (as it may have come in from definite parts of electrical science); and that

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practical and theoretical investigators should be allowed to develop their ideas freely. In short, Conventions or Committees should not meddle with matters (save very lightly) which are in a provisional stage. And I may add that, just as treaties are made to be broken, so the laws of Conventions (not the lords of Convention) will be broken as soon as ever it is found inconvenient to obey them. The introduction of anything of the nature of officialism into scientific matters should be strenuously opposed, in *this* country. It would be as bad as the passport system. The utility of a Convention seems to be to consist in the formation of a temporary consensus of opinion, from which to make fresh departures. There cannot be any finality.

Mac.—Here we are on firmer ground. There cannot, I think, be any question that this is the right name for the practical unit of inductance, in honour of the man who knew something about self-induction, and whose ideas on the subject are still to be fully appreciated. This was very much his own fault. He had the most splendid and thoroughly philosophical ideas on electro-magnetism all round, but kept them too much in the background. Maxwell's treatise requires to be *studied*, not read, before the inner meaning of his scheme can be appreciated. Had he lived he would probably, in some future edition, have brought his views prominently forth *ab initio*, and developed the whole treatise on their basis exclusively. Should the mac be 10^9 or 10^6 centimetres? If 10^9, which has great recommendations, then millimac will be practically wanted to avoid decimals. It is quite a euphonious and unobjectionable word.

Inductometer.—Naturally, in accordance with induction, inductivity, and inductance, a measurer of inductance (self or mutual) in terms of units of inductance, macs, or millimacs. I would apply the term to any instrument that measured inductance at once in terms of known inductances, as resistances are compared with known resistances. Some practical acquaintance with self and mutual induction, desultory, but of long continuance, has gradually forced upon me the idea (not to be easily displaced) that really practical ways of measuring inductances should be in terms of standard inductances, or, which is the same thing, by a properly calibrated inductometer, and not absolute measurements. What particular method of making the comparisons is best I do not know, nor yet how best to calibrate the inductometer. If it were a mere question of coils of fine wire, nothing is simpler or more expeditious or more accurate or more sensitive than the immediate balancing of the self-induction against that of an inductometer of *variable* inductance, using the telephone. The advantages and the simplicity are so great that I think practical men might well turn their attention to practical ways of extending the method to cases other than those in which mere coils alone are concerned.

"Absolutism."—The most absolute of all ways of finding the inductance of a coil is with a tape. Herein lies a moral of very wide application.—Yours, &c,

OLIVER HEAVISIDE.

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read several articles in your paper arising in the first instance out of the marked difference in the estimate for lighting Lord-street, Southport, and I trust the few suggestions I am about to offer may help to assist the matter forward.

I have long contended that for all installations of any importance it is unwise to go indiscriminately to a lot of electric light contractors—some good and some bad—and get an assortment of tenders for all kinds of different methods of lighting, some, like the contractors, good, and some bad. In my opinion if an installation is put to public tender a gentleman of known experience should be called in by the firm, company, or corporation, who require the light; he should be carefully informed in every detail as to where the light is required, about the necessary quantity of light, and should then prepare and submit a complete specification, drawn up in the form of a regular engineering specification, and this should be tendered to in all cases. I notice that "Plonmel" gives a table of areas illuminated by lamps of various candle-powers, suggesting that all tenders should be given on the equal basis of so much light per foot. Whilst I agree to some extent to his suggestion, it is apparent that in many cases such a rule could not hold good, because a uniform light for all classes of illumination is, in the first instance, incorrect; and, secondly, the contractors are then in about the same position as before, from the simple reason that if the artistic arrangement of the lamps is considered from different points, each tender would be on a different basis, so that I am firmly of opinion that there is only one real way out of our difficulties, that being, as I suggested before, to place the work into the hands of a reliable consulting electrical engineer. I say electrical engineer instead of electrician because so many men are electricians only and not engineers at all. It must be clear that it is not electrical knowledge only that is required, but a sound, practical engineering experience, which will enable a man to determine the best arrangement of his motive power and dynamos—which, after all, are the most important parts of the installation—and also with sufficient electrical knowledge to enable him to clearly determine the most efficient and substantial arrangement for the erection of the cables, lamps, &c.

Such a course as this not only places the purchaser in a position where he has the advantage of a man's experience and guidance, but the contractor knows exactly what he has to supply to comply with the specification; he also feels that he is dealing with a man of experience who is capable of deciding any question that may arise, and prevent disputes or differences on either side.

Whilst upon the subject of tenders for electric light installations I should like to say a few words about the way tenders are sent in to the purchasers.

I have in many cases tendered for installations, sending complete specifications, tenders, and drawings, whereas my competitors have simply tendered, without accurately stating what they intend to supply. For instance, on one occasion I was asked to tender for an installation, and the following specification was read out from a tender they had received:—"1 120-light dynamo, 1 main switch, 60 16 candle-power incandescent lamps, 60 lampholders, 60 factory pendants, 440 yards insulated cable for pit, 880 yards insulated cable above ground."

Now, anyone who understands the subject will see at a glance that any one of the items in the above means practically anything, as neither the speed of the dynamo, description of switch, kind of lampholders, what sort of pendant a factory pendant is, and lastly, but not least, what does insulated cable mean, is stated.

As this tender was given by a firm who have a good reputation, it probably was not so misleading as it might have been; but I took the opportunity of sending in two tenders, one in the style of my competitor, and one as I thought it should be done. Of course the two prices were very different.

In conclusion I can, for your satisfaction, state that my conclusions are not merely thoughts, but the convictions I have arrived at after actual experience, and I am sure that although my suggestions may not meet with the approval of some people, yet I feel satisfied that any firm who intend to do the work really well and conscientiously would much prefer working under an engineer to dealing with people who do not understand the work or what they want, and unfortunately sometimes think they do.—Yours, &c.,

W. C. MOUNTAIN.

For the Gülcher Electric Light and Power Company (Limited).

Battersea Foundry, S.W., June 20th, 1887.

THE NEWTON PRIMARY BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your kind notice of the "Newton Primary Battery" exhibited by us, we beg to point out that the statement to which you apparently take exception is fully justified by the facts of the case, for by the system alluded to the electric light can be supplied to consumers at a price not

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higher than gas at 4s. 6d. per 1,000 cubic feet, which we maintain is a reasonable figure, seeing that 7s. 6d. is charged for gas in places not 100 miles from London.—Yours, &c.,

SAM. TUGMAN, Director,
The New Electric Light Syndicate.

2A, West-street, Finsbury, 23rd June, 1887.

THE VARIATION OF THE RESISTANCE OF FAULTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have, of course, read with much interest Mr. Kennelly's paper on the variation of the resistance of faults, and also Prof. Jamieson's letter on the subject in your number of May 6th. I am rather surprised, however, that Prof. Jamieson did not see that in the example he gives my formula correctly expresses the resistance of the cable up to the fault, according to Kenney's law. For,

Let x = the resistance up to the fault,
y = the resistance of the fault when tested with 40 cells.

Then, according to Kennelly's law, $\sqrt{4}\,y$ or $2y$ = the resistance of the fault when tested with 10 cells.

Prof. Jamieson has correctly given my formula for the resistance of the cable up to the fault as $\frac{n\,B - A}{n-1}$, where B is the resistance of the cable and fault when tested with the larger number of cells, and A the resistance of cable and fault when tested with the smaller number of cells, $2\ n$ to 1 being the ratio between the number of cells used in the two tests.

When the ratio is 4 to 1 this formula becomes simply $2\,B - A$, as Prof. Jamieson has shown—

Then $B = x + y$,
and $A = x + 2\,y$,
according to Kennelly's rule.

Therefore $2\,B - A = 2\,(x+y) - (x+2\,y) = x$ = the resistance of the cable to the fault, so that for this ratio of 1 to 4 my formula agrees with Kennelly's law, supposing that the currents passing through the fault vary with the number of cells used.

If we take n as the ratio between the cells used in the two tests my formula will be

$$x = \frac{\frac{n}{2}B - A}{\frac{n}{2} - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and the corresponding formula according to Kennelly's law will give

$$x = \frac{\sqrt{n}\,B - A}{\sqrt{n} - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

It will be seen at once that these formulæ agree when $n = 4$.

My formula was based on a large number of observations made many years ago. Within certain limits I found that the ratio of the resistances of the fault was one half the inverse ratio of the number of cells used. Thus, if the ratio of the cells were 1 to 4 the ratio of the resistance would be 2 to 1. If the ratio of the cells were 1 to 6 the ratio of the resistances would be 3 to 1, and so on, and the formula was founded on these observations. The measurements should always be taken with zinc to line; perhaps the neglect of this was the reason Prof. Jamieson's results were not altogether satisfactory.

As far as I remember the observations were made in 1873. I gave the formula to Mr. Cuff, of the Eastern Extension Telegraph Company, and the test was first used by him when the Singapore Hong Kong cable was broken, during a typhoon about 1874 or 1875, when the ratio test was the only one which gave the position of the break with anything like an approach to accuracy.

I did not publish the formula, partly because it is inapplicable to the ratio 1 to 2 in the number of cells, and I found on further experiment, I believe, that the alteration in the resistance was only apparent. I am, however, much obliged to Prof. Jamieson for referring to the formula.

I am not sure whether I still have a record of my numerical results, but they gave me what I required at the time, namely, a means of eliminating the resistance of the fault. I shall in any case repeat the observations now that the subject has been so ably brought forward by Mr. Kennelly, and endeavour to discover the reason for the difference between his results and mine.

According to my results we get formula (1) as follows:—

With current C we have

$$A = x + \frac{n}{2}y \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

With current $n\,c$ we have

$$B = x + y \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Then from (3) we get $y = \frac{2A - 2x}{n}$,

and from (4) $y = B - x$.

Equating these values of y we have

$$B - x = \frac{2A - 2x}{n},$$

from which we get

$$x = \frac{n\,B - 2\,A}{n-2} \text{ or } \frac{\frac{n}{2}B - A}{\frac{n}{2} - 1}$$

According to Kennelly's results we get formula (2) as follows:—

With current C we have

$$A = x \times \sqrt{n}\,y \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

With current $n\,c$ we have

$$B = x + y \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Then from (5) we get $y = \frac{A - x}{\sqrt{n}}$,

and from (6) $y = B - x$.

Equating these values of y we have

$$\frac{A - x}{\sqrt{n}} = B - x$$

From which we get $X = \frac{\sqrt{n}\,B - A}{\sqrt{n} - 1}$.

In each case the resistance of the fault is eliminated.—Yours, &c.,

G. K. WINTER, M.I.C.E., M.S.T.E.,
Telegraph Engineer Madras Railway.

Arkonam, 27th May, 1887.

SPECIFICATION.

SPECIFICATION FOR CERTAIN COMPONENT PARTS OF STANDARD IRON TELEGRAPH POSTS FOR THE GOVERNMENT OF INDIA.

[We think that many of our readers will be glad to read the specification for telegraph and other material issued by the India or other offices from time to time, and therefore we give the following specification relating to telegraph posts, tenders for which have to be sent in before 2 p.m. on Tuesday, June 28, 1887.—ED. *E.*]

1. All the component parts are to be of the best materials and workmanship, and to be made in accordance with the drawings and patterns, which may be seen on application to the superintendent of the India Store Depot, Belvedere-road, Lambeth, S.E.

2. *Sole Plates.*—The sole plates are to be made of the best grey metal, cleanly cast and blackened. To test the fitting of the screws, 1 per cent. of the sole plates shall be screwed on to the sockets. In the event of any misfit the whole may be screwed on. By misfit in this case is meant a sole plate not entering on the screw of the socket sufficiently to take $1\frac{1}{4}$ complete turns. The thickness of the corrugated web to be $\frac{3}{16}$ of an inch.

3. *Sockets.*—The sockets are to be made of the best grey metal, cleanly cast and blackened, and in order to ensure the concentricity of the cast-iron sockets, the contractors shall have the bearings of the core barrels and seatings of the moulding boxes, with which they are made, turned and bored respectively. Five per 1,000 of the rough castings will be broken at the expense of the contractor, to determine their accuracy in this respect.

4. *Caps.*—The caps are to be made of the best annealed malle-

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able cast iron, and are to be well galvanised with pure zinc. The socket in the cap is to be rimered out and gauged for size. A manufacturing margin of $\frac{1}{16}$ of an inch, either upwards or downwards, will be allowed for the entrance of the gauge. A ring and plug gauge, corrected to the standard at the India Store Depot, will be supplied to the manufacturer on his tender being accepted, and is to be returned to the superintendent of the India Store Depot on the completion of the contract.

5. Each sole plate, socket, and cap is to have its distinguishing letter, the India Government mark, the letters T. D., the name of the contractor, and the year of manufacture cast on it, thus ;—

$$\begin{array}{c} \wedge \\ | \\ \mathrm{I} \\ \mathrm{B.} \quad \mathrm{T.\,D.} \quad \mathrm{Z.} \quad . \quad . \quad . \quad . \quad \& \mathrm{Co.} \\ 1887 \end{array}$$

in block letters and figures, which must be well defined.

6. *Tubes.*—The galvanised wrought-iron tubes are to be of B. B. S. iron, equal in quality to pattern No. $\frac{2845}{\mathrm{H}}$ at the India Store Depot. Samples of the iron proposed to be used are to be submitted for the approval of the superintendent of the India Store Depot before the manufacture of the tubes is commenced. The letter distinguishing the size of a tube is to be punched out of the metal of the outside hoop at the bottom of the tube before it is riveted on. The inner strengthening rings of the tubes are to be driven home hard, the drawings merely showing their normal position.

7. The rivets for the galvanised wrought-iron tubes must be of such a quality that they will stand riveting cold.

8. The wrought-iron tubes, inner strengthening rings, and outside hoops are to be well galvanised with pure zinc, before and after they are put together. The zinc is to be evenly deposited and free from spots.

9. The superintendent of the India Store Depot or his deputy may be present during the whole process of making the component parts specified in the schedule, and they shall have every facility for seeing them during all stages of their manufacture ; but samples of the finished work are to be forwarded for approval, free of expense, to the superintendent of the India Store Depot, from time to time, as he may direct.

10. To ensure that all the component parts fit, there is in the drawings a dotted line called the "fitting line." When the posts are taken for testing purposes, the superintendent of the India Store Depot, or his deputy, will choose at random the component parts to be fitted together. On their being so fitted, should they find that any one component part in the total quantity either does not reach, or passes, this "fitting line" by more than 2in., they shall gauge one per 1,000 ; if they find another misfit they shall gauge 10 per 1,000, and a third out of gauge will cause the whole quantity to be gauged. In such cases the portions to be gauged are the outer upper diameters of the sockets, and the inner lower and the outer upper diameters of each tube, except tube A, which must be gauged for inside diameters at both ends.

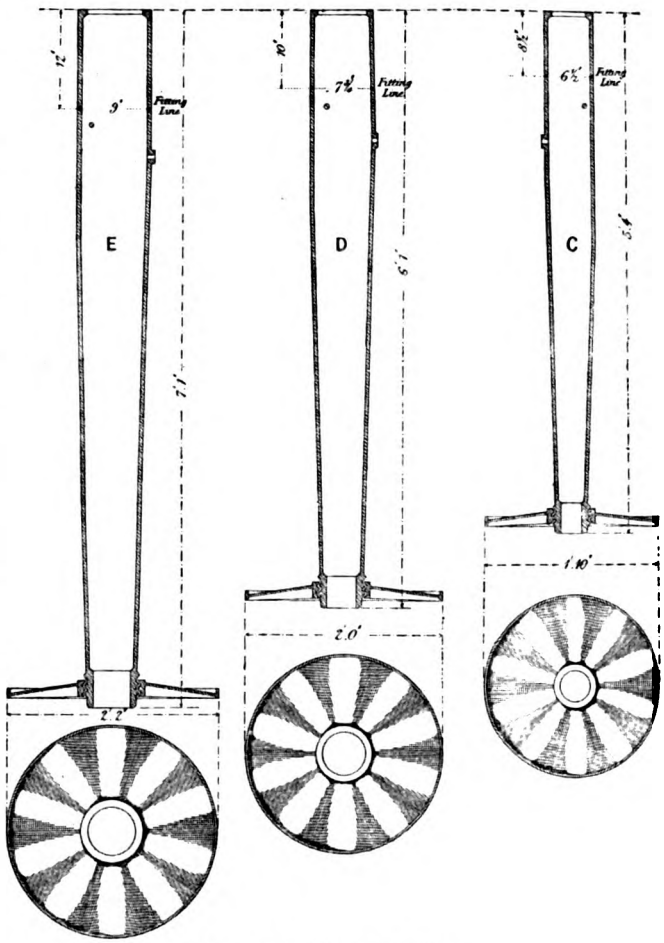
11. The following table gives the minimum breaking weight and minimum weight at which each size of a complete post of two galvanised tubes and a socket may take a permanent set of a curve with a versed sine of half an inch :—

Size.			Breaking weight.	Weight for working load and permanent set of not more than $\frac{1}{2}$in.
Tube.		Socket.	Lbs.	Lbs.
A, Z	with	Z	400	274
A, B	,,	B	500	344
B, C	,,	C	840	576
C, D	,,	D	1,500	1,033
D, E	,,	D	2,400	1,650

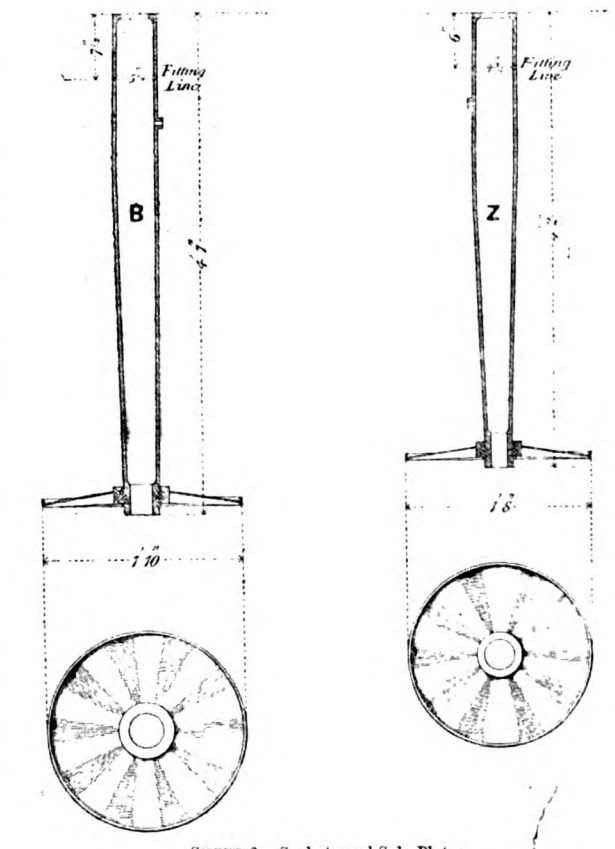
These are the actual pulls or dead loads at the line of wires when the posts are in working order or vertical, but, as the whole are to be tested horizontally, two-fifths of the average weight of the two tubes, taken in even pounds, is to be deducted for the overhanging weight of the post itself.

12. The component parts being ordered singly, the tests for minimum breaking strength, and also for working strength and permanent set, are to be determined exactly according to the foregoing table, and, where needed, the necessary lengths to make out the full length shall be furnished for purposes of testing by the contractor. The strength of the A 5ft., and of the Z tubes, shall in all cases be at least equal to that specified for the B, C posts, both for the minimum breaking strain and also for the working strain giving the permanent set.

13. One per 1,000 of the galvanised tubes will be tested up to destruction. Should they not all give the required test, one per 100 must be tested to the minimum breaking strain ; if, then, one per 100 should break at less than the minimum breaking strain, 10 per cent. of the quantity submitted for examination must be tested to the minimum breaking strain, and, if it be found from this that more than one per cent. has broken at less than the minimum breaking strain, the whole must be absolutely rejected.



SHEET 1.—Sockets and Sole Plates.



SHEET 2.—Sockets and Sole Plates

14. The tests will be conducted as follows :—The tubes and sockets to be tested shall be fitted together, and the whole laid

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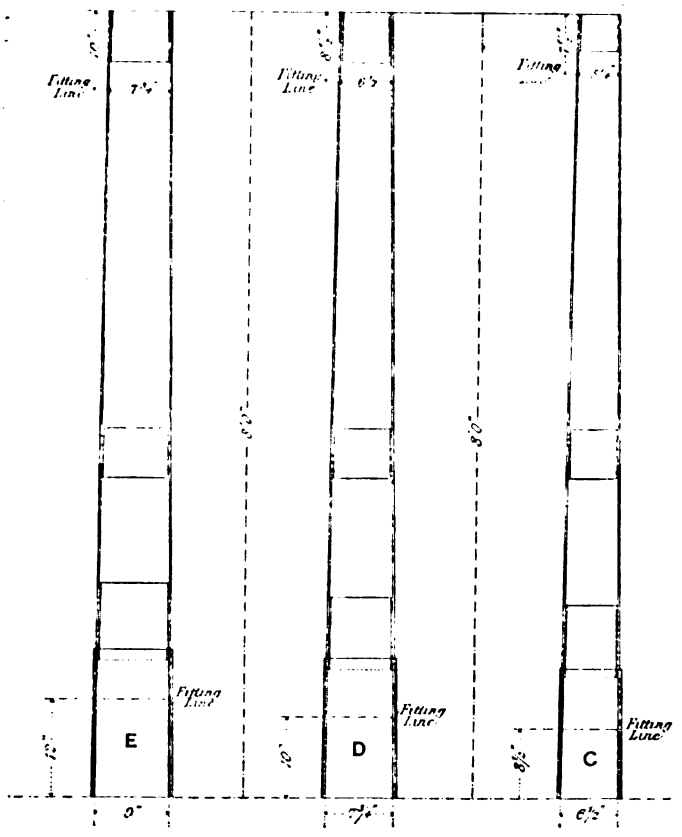
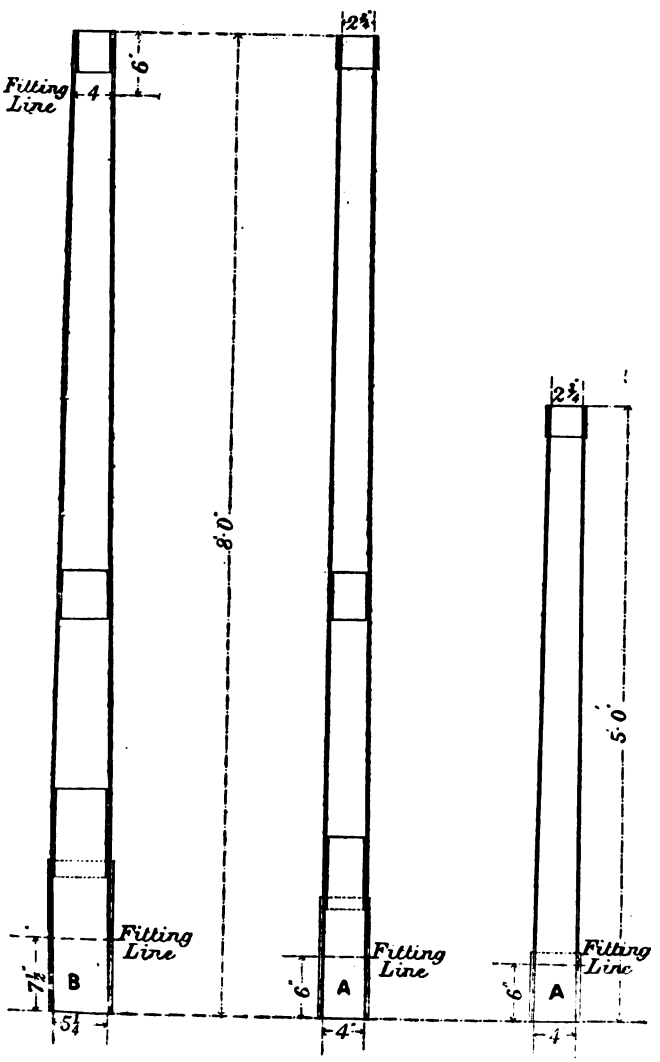


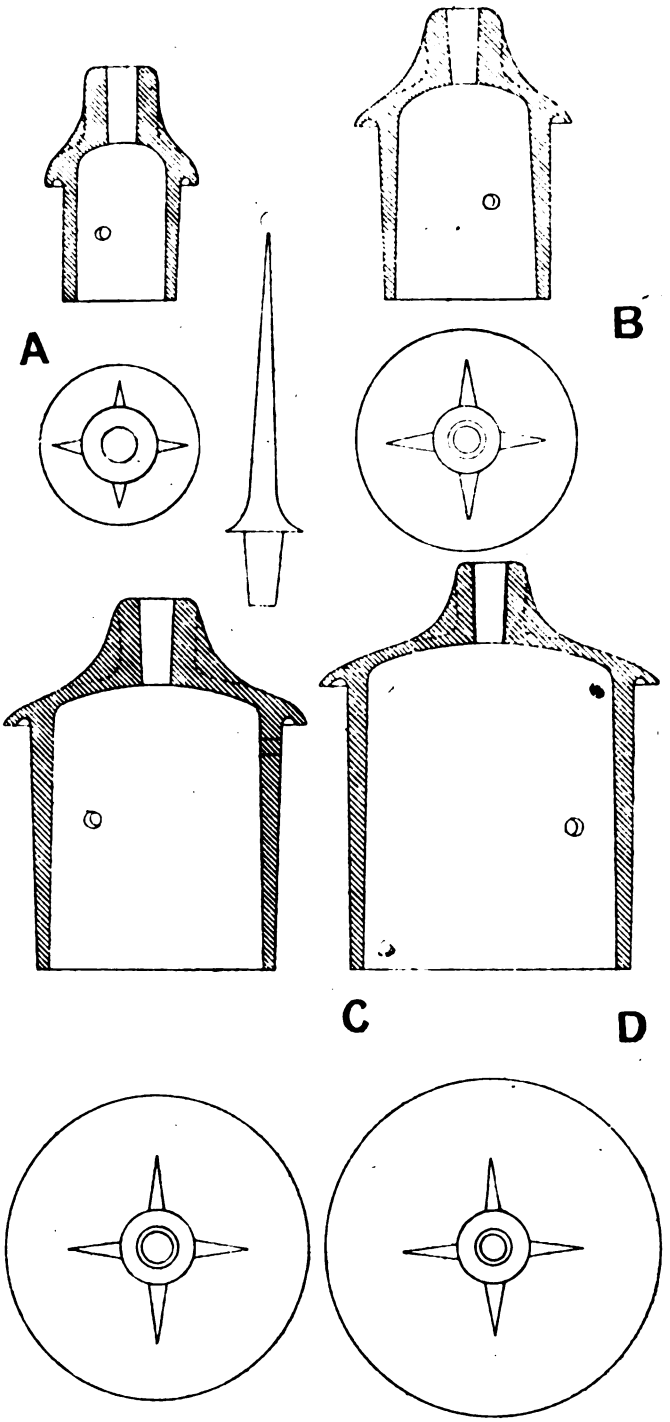
SHEET 3.—Galvanised Tubes.



SHEET 4.—Galvanised Tubes.

horizontally, so that the total weight shall rest upon a support at the ground line of the socket, viz., 1ft. from the bottom of the lower galvanised wrought-iron tube, and no part of the support is to be brought nearer the bottom of the lower tube than 1ft., a shackle or strap holding down the socket at the bottom end, the post being thus supported on its working fulcrum. The test load shall then be hung on at the line of brackets, or 1ft. from the top end of the post.

15. In testing for permanent set, the tubes and sockets shall be fixed in the same way as described above, and the working or dead permanent set test load, as shown in the above table, shall be hung on the post at the line of brackets, or 1ft. from the top end, and with



SHEET 5.—Galvanised Caps and Lightning Discharger.

this load the permanent set, measured as a versed sine from a chord stretched from the bottom to the top of the galvanised wrought-iron portion of the post, after the weight is removed, shall not exceed half an inch.

16. The testing shall be performed by the Superintendent of the India Store Depot, or his deputy, for which purpose the contractor must supply all necessary machinery, apparatus, a complete set of gauges and templates, convenience, labour, and assistance of every kind required for the purpose, without making any claim or charge for the same, it being distinctly understood that these expenses are included in the prices stated in the tender. All tubes or sockets

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broken or otherwise destroyed in testing, and any additional lengths required, as mentioned in paragraph 12, are to be at the expense of the contractor. All testing apparatus, &c., is to be under the control of the Superintendent of the India Store Depot, or his deputy, during the period of examination.

17. The galvanised caps are to be packed in cases made of 1in. (full) deal, with two battens each top and bottom, and to be bound with 1in. hoop iron. Each case is to contain 25 of the A size. The packing is to be done to the entire satisfaction of the superintendent of the India Store Depot or his deputy. Instructions for marking the cases will be forwarded by the superintendent of the India Store Depot when the stores have been approved. Should any damage be discovered on the arrival of the stores in India which may be attributable in any way to defective packing, the contractor will be held responsible for any loss that may arise therefrom.

18. Proper accommodation, under the control of the superintendent of the India Store Depot or his deputy, is to be provided by the contractor for the storage of approved and the distinct and safe custody of rejected stores until finally disposed of.

SCHEDULE.

D. O. 5539,

Home, No. 174. Bombay and Madras. 16 Telegraph.

Telegraph Indent, No. 27, of 2nd May, 1887.

Standard Iron Telegraph Posts, Component Parts	Pattern Number at India Store Depot.	Quantity required.			Weight of each part.
		For Bombay.	For Madras.	Total.	
	For make	No.	No.	No.	Cwt. qr. lb. oz.
Caps, A	A, 1884	—	500	500	0 0 2 6
Tubes, A, 5ft....	A ,,	800	600	1,400	0 0 19 0
,, A, 8ft....	A ,,	1,200	500	1,700	0 1 3 0
,, B, 8ft....	B ,,	15,100	—	15,100	0 1 24 0
,, C, 8ft....	C ,,	13,100	—	13,100	0 2 14 0
Sockets, B	B ,,	—	400	400	0 2 9 0
,, C	C ,,	—	4,200	4,200	0 3 7 0
Sole plates, B ...	B ,,	—	300	300	0 1 4 0
,, ,, C ...	C ,,	—	4,100	4,100	0 1 4 0

To be supplied in accordance with the annexed specification.

N.B.—The tender should state the earliest date by which the contract could be completed.

[Five sheets of drawings accompany the specification. These drawings have been reduced, and are given herewith.—ED. *E.*]

THE ELECTRO-DEPOSITION OF IRON.

BY PROF. W. CHANDLER ROBERTS-AUSTIN, F.R.S.

The great interest which would attend the investigation of the properties of pure iron has long been recognised, and although but few results have as yet been obtained, elaborate preparations for such an inquiry have from time to time been made. A committee appointed by the British Association described in 1869 a method which yielded iron of a high degree of purity, the work being entrusted to the late Prof. Matthiessen, who ignited pure ferrous sulphate mixed with sodium sulphate, reduced to oxide of iron, so obtained by pure hydrogen, and melted the spongy iron in a lime crucible before the oxy-hydrogen blow-pipe. The committee reported "that, with regard to the physical properties of pure iron, owing to the want of time, nothing has as yet been accurately determined." It appears, however, that many of the physical properties of the pure metal differ considerably from those of the commercial. The work appears to have been interrupted by Matthiessen's lamented death, which occurred in the following year. It may be that metallurgists have been satisfied that Bessemer metal is sufficiently pure to afford a basis for investigation without resorting to elaborate chemical methods of preparation, for but little has hitherto been done to prepare on a large scale a material in which the above-mentioned impurities are entirely absent. The volume of the reports of the British Association, to which reference has just been made, also embodies a paper by M. H. Jacobi, of St. Petersburg, whose name is so well known in connection with electro-metallurgy. M. H. Jacobi and M. Eugène Klein took out a patent in this country in 1869 (No. 2,456), which was, however, allowed to lapse. Jacobi worked for some days in the mint laboratory, and communicated to me the details of the methods of manipulation, and in 1870 I visited St. Petersburg, and had the advantage of seeing the iron deposited on a large scale with a view to the preparation of plates to be used for printing the paper money of Russia.

The deposition of iron is attended with many difficulties, and in this country, so far as I know, iron has only been deposited electrolytically on a very small scale, and the metal deposited has been considered rather a metallurgical curiosity than as possessing any practical value. It may be well to describe briefly the method of procedure. "The bath used is a solution of ferrous sulphate and magnesium sulphate in equivalent proportions of specific gravity 1·155. The solution must be so far neutralised by the addition of magnesium carbonate that blue litmus paper barely shows any acid reaction. A wrought-iron anode of about the same size as the object which is to receive the deposit must be employed, and the best interval between the poles proved to be 4 c.m. The secret of success appears to be in the use of very feeble currents. Mr. W. H. Preece, F.R.S., electrician to the Post Office, has kindly afforded me facilities for determining the strength of the currents employed, and it may be sufficient to state that the current best suited for the deposition of an iron medallion, the surface of which measured 560 sq. c.m., proved to have a strength of only 0·089 ampere, and such a current was yielded by two Smee's cells, each having a silver plate of 50 sq. c.m. area coupled up for intensity. The only objection to the process is the length of time required for its completion. It was not found possible to deposit such a medallion of sufficient thickness for use in the reducing machine in less than three weeks. The adherence of the deposited iron to the surface of the copper gives rise to considerable difficulty in detaching it, and in order to reduce this adherence it was found best to throw down on the copper model a thin film of nickel, and after exposing this for a short time to the air in order to slightly tarnish its surface to cover it with a second film of nickel, on which the iron was subsequently deposited. Even when this precaution was taken several moulds were spoilt by partial adherence of the iron and copper through the nickel. I am now conducting some experiments on the deposition of iron on copper moulds covered with a thin layer of silver iodide, that substance being well known as an excellent conductor." The metal has a high degree of purity. Mr. A. Dingham, a skilful analyst in my laboratory at the Royal School of Mines, finds that a specimen submitted to certain physical tests, to which reference will be made presently, contained only the slightest trace of magnesium and 0·005 per cent. of sulphur. Its density is 7·675, which becomes 7·811 when the metal is annealed. By annealing carefully-measured strips of metal they were found to contract about 1 per cent. of their length. I found in 1869 that the metal as deposited occludes from 17 to 20 times its volume of hydrogen. Cailletet showed that iron deposited under certain conditions occludes 248 times its volume of hydrogen, the pressure of which gas renders the metal very hard, and augments considerably its coercive force when magnetised. Notwithstanding the purity of the metal its magnetic capacity does not appear to be high. Tested by the magnetic balance designed by Prof. Hughes, it would appear to possess less than two-thirds the magnetic capacity of a strip of Russian sheet of the same dimensions. The magnetic capacity of the strip of electro-iron rises considerably when the metal is annealed, which tends to show that the defective magnetic quality is due to the aggregation of the metal, and not to impurity, as well as to the partial expulsion of the occluded gas. With a view, however, to set this important question of magnetic influence at rest, I have deposited a carefully-turned rod of copper, 1·01 foot in length, 0·511 inch in diameter, and of a maximum thickness of 0·035 inch. Dr. John Hopkinson having expressed a wish to conduct some experiments in this direction, the rod (now exhibited) will be placed in his hands.

From the point of view of its molecular structure the electro-deposited iron promises to afford interesting experimental results. Strips of the iron about 5·4 inches in length, 0·033 inch in thickness, and 0·75 inch in breadth, were tested for tensile strength. It was found that the deposited metal crushed in the jaws of the machine, and it was therefore necessary to anneal the ends of the test piece before submitting it to stress. A piece of deposited iron so treated broke in the centre of the strip with a load of 2·7 tons per square inch. A similar strip annealed at the temperature of molten zinc (about 412° C.) was found to possess a tensile strength of 13½ tons per square inch, and another piece annealed at a temperature between the melting point of silver (940° C.) and that of the melting point of aluminium (about 300° C.) had a tenacity of 15½ tons per square inch, two separate experiments agreeing very closely. The elongation was in each cast very small, and very delicate instruments would be required to determine its amount with accuracy. It will thus in future experiments be possible to examine by photographic methods, described by Mr. Sorby, the change in structure of a pure, brittle, and non-coherent metal to one having a considerable tenacity.

The use of electro-deposited iron for printing purposes has already been mentioned. One other application remains to be described.

Many years ago I suggested that electro-deposits of iron should be employed with a view to test the capabilities of a machine devised for reducing designs modelled in low relief, and the reproductions in metal and ivory were so faithful that the superiority of such iron deposits to the metal casts or copper electrotype ordinarily employed was at once demonstrated.

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The preparation of the dies for the coins to be struck on the occasion of the Jubilee of Her Majesty the Queen presented a favourable opportunity for the more extended application of similar deposits of iron. The designs modelled in plaster were reproduced in "intaglio" by the electrolytic deposition of copper, and on the copper moulds so prepared iron was deposited. The iron proved to be hard and of excellent quality, and up to the date of this paper obverse dies of all denominations of gold and silver coin, as well as the obverse of a medal, have been produced by a reducing machine from such deposits.

If they were to take a plate of copper and deposit on it a layer of iron, then glue to the back of the iron a piece of wood, and wrest the iron away from the copper, the iron did not separate cleanly, but the iron slipped off copper, just as it was asserted that a bank-note could be split by glueing it between two surfaces of wood. What this meant he did not at present know, but it was a question that he was investigating. The paper was by no means in a state in which he could have wished to present it to the Institute; but he thought that the interest attached to the exhibition for the first time in London of a medallion, and that medallion in iron, and a portrait of Her Majesty, was likely to be of far more interest to the members of the Institution than any remarks he could have to offer in the interval between now and the next meeting.

THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION, AND CAPACITY.

BY W. E. SUMPNER, B.SC.

(Continued from page 128.)

Fig. 3 represents a method of comparing two capacities. We may regard the branch s as having an effective self-induction of

$$\frac{r}{p} \cdot q^2 K_q - s^2 K_s$$

Fig. 4 represents a method of comparing mutual induction with capacity. We may regard the effective self-induction of the branch r as being

$$\pm\frac{s+q}{q} M_{rb} - qr K$$

Fig. 5 represents Maxwell's method of comparing self-induction with capacity. We may regard the effective self-induction of the branch r as being

$$L_r - qr K_q.$$

Fig. 6 represents Maxwell's method of comparing self-induction with mutual induction. The effective self-induction of the branch s is

$$L_s \pm \frac{p+r}{p} M_{sb}.$$

Figs. 7, 8, 9 represent analogous methods of finding self-induction, mutual induction, and capacity. The effective self-induction of the branch s is L_s for Fig. 7, $\frac{p+r}{p} M_{sb}$ for Fig. 8, and $-s^2 K_s$ for Fig. 9.

Fig. 10 is an illustration of the combination of the above methods. The effective self-induction of the branch s in this case is

$$L_s - ps K_p \pm \frac{s+q}{q} \cdot \frac{q}{p} M_{rb} - \frac{q}{p} L_r.$$

The interest of the above methods consists in the fact that they are methods to measure absolutely the difference between two quantities. The most accurate way of measuring the ratio of two resistances is well known to be that of Prof. Carey Foster, who measures the difference between two nearly equal resistances in terms of the resistance of an observed length of a uniform wire; and by that means, if either of the resistances is known fairly accurately, their ratio can be determined with extreme accuracy. The above methods are analogous with that of Prof. Carey Foster.

When, however, we employ the cumulative method exemplified in the secohmmeter of Profs. Ayrton and Perry, the analogy is still more complete. In using a wire bridge it is very difficult to determine the exact position of the slider, although it is very easy to determine accurately the difference between two of its positions; and the great accuracy of Prof. Foster's method is due to the fact that it is not necessary to determine the absolute position of the slider, because all that is required is the difference between two positions. Now, one of the faults of Maxwell's methods consists in the necessity of having a very exact balance of the bridge. As an example, when the branches r and s were each about 6,000 ohms, it was found necessary to adjust r to a small fraction of an ohm by adjusting the length of a bare wire connecting two terminals, and even then the heating caused by keeping on the battery for a moment so altered the balance that a correction had to be applied. However, when the cumulative method of Profs. Ayrton and Perry is employed, it is not necessary to have the bridge balanced at all. It is only necessary to have the bridge so nearly balanced that the spot may be on the scale.

This result is a simple deduction from equation (13) of the paper of Profs. Ayrton and Perry. It may also be proved as follows:—If there is no induction in the bridge, but the arm s is deranged from balance by an amount σ_0, the deflection D_0 of the galvanometer will be proportional to σ_0 for small derangements; so that

$$D_0 = k\sigma_0,$$

k being a constant. If the battery is on for only a portion (l) of the time, the deflection D_0^1 will be l times this; so that

$$D_0^1 = (l D_0) = lk\sigma_0;$$

and if we increase the branches r and s by small amounts proportional to r and s the deflection will not be altered. Now, in testing for self-induction we practically increase the resistance of the arm s by an amount σ in consequence of the self induction, and in order to find out what is the value of σ we increase the arm r by an amount which bears the same proportion to p that σ does to q. We shall know this is the case when the deflection of the galvanometer is $l D_0$, where l is the lead of the secohmmeter, *i.e.*, the proportion of the time the galvanometer and battery are on together to the period of the commutator. So that, in testing with the secohmmeter,

(1) Observe the position of rest (Z) of the spot.

(2) Adjust the bridge roughly for resistance until the spot comes to a point, D_0, not far from Z.

(3) Take a point on the scale between these two, such that its distance from Z bears to the distance between Z and D_0 the proportion of the lead of the instrument, and use this point as a zero.

(4) Derange the bridge by a known amount, and turn the secohmmeter till the spot of light passes slowly through the zero. At this moment press the key and take the speed reading.

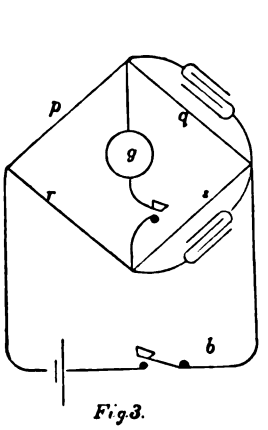

Fig. 3.

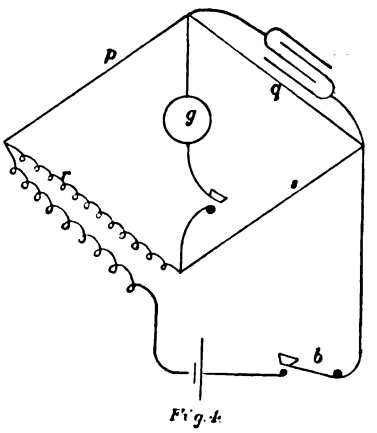

Fig. 4.

By this method only one error of judgment can arise, viz., the determination of the speed.

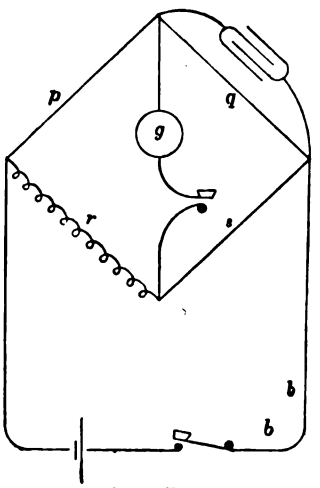

Fig. 5.

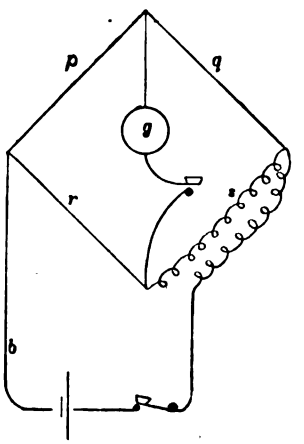

Fig. 6.

The analogy with the method of Prof. Foster is clearly shown by the fact that the same wire bridge can be used. If, as in Fig. 7, the resistance $p+q$ be that of a straight uniform wire, we have—

1. For resistance balance—

$$s : r = q : p,$$

or

$$s : r+s = q : q+p.$$

2. For commutative balance—

$$s+\sigma : r+s+\sigma = q' : q'+p',$$

where σ is the effective increase of resistance owing to self-induction.

$$\sigma = \frac{n L_s}{l},$$

n being the number of revolutions per second, and l the lead. q' is the new value of q', and $q'+p' = q+p$.

Now, generally, σ is small compared with s; so that

$$\sigma : r+s = q' - q : p+q,$$

and

$$L_s = \frac{l}{n}(q'-q)\frac{r+s}{p+q}.$$

The two chief advantages of the cumulative method are—

(1) Impulses are turned into steady currents as far as galvanometers are concerned, and therefore null methods are applicable which would otherwise be impossible.

(2) The sensibility of the galvanometer is practically multipled by the speed of the commutator. The only limit is that given by the ratio

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between the period of the commutator and the time constant of the network, *i.e.*, the time needed for currents to completely establish themselves.

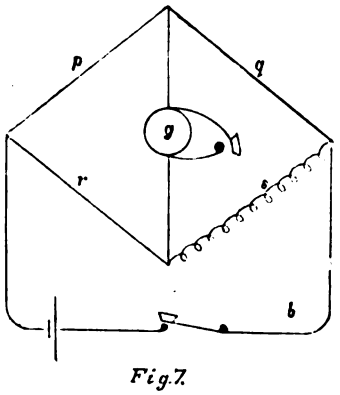

Fig. 7.

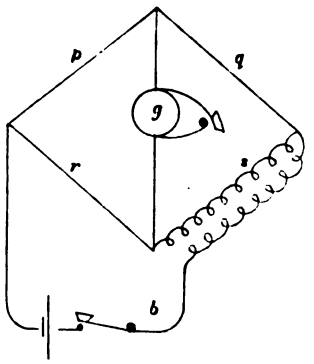

Fig. 8.

This renders it possible to much improve any existing null method, however good.

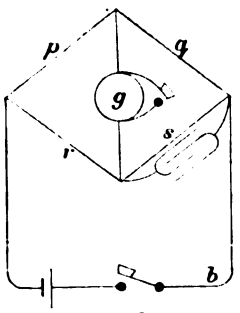

Fig 9.

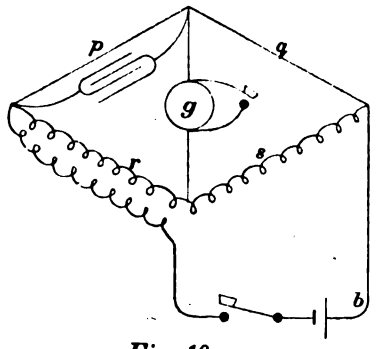

Fig 10.

The sensitiveness of any of the above-mentioned difference methods depends upon three considerations—

(1) The sensitiveness of the arrangement of the bridge for the measurement of resistance.

(2) The time constant of the bridge.

(3) The amount of the difference measured.

Thus, in order to determine the ratio between L and M accurately by the method of Fig. 6, it is necessary to remember that

$$L - a\,M = b\,D + \frac{\sigma}{N},$$

where D is the deflection caused by a small derangement from the null position, and a and b are constants; N is the speed reading of the secohmmeter, and σ the apparent increase of resistance. The most advantageous value of b will be given by (1) and (2), combined with the consideration that, other things being equal, it is best to have a as nearly equal to L/M as possible.

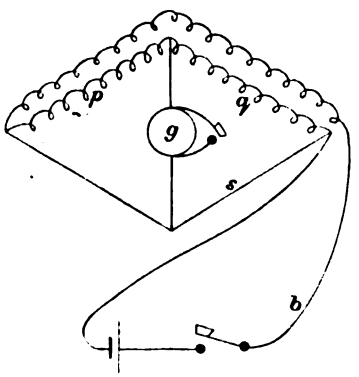

Fig 11.

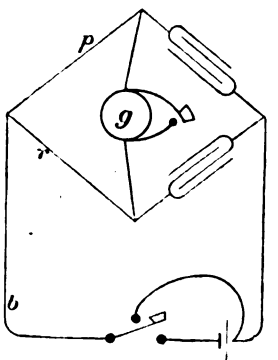

Fig 12.

If the comparative methods of Maxwell can be rendered delicate by cumulation, all that is required for practical purposes is done, for we have good standards of capacity, and coils of wire having constant self-induction can easily be made. If, however, the effects are not accumulated, it seems as though no comparative null method of measuring these quantities can be more delicate than would be the measurement of resistance by a Wheatstone bridge, if it were only possible to touch the battery key for an instant. This process is employed when the bridge is far from balance in order to prevent the effect on the galvanometer from being too great, and this is the process which must be used in the measurement of induction and capacity, since their effect vanishes after the first instant. Even the comparative method of Prof. Carey Foster, excellent as it is, could be much improved by using a cumulative method, not only because the galvanometer is rendered more sensitive, but also because a slight difficulty which renders a very exact balance impossible could be overcome—viz. unless the galvanometer is very ballistic, the condenser effect asserts itself before the mutual induction effect and produces a slight "kick" on the galvanometer, which it is difficult to allow for accurately.

If the cumulative method be employed, and the readings for different speeds plotted, the points should lie on a straight line. As the zero point on this line is absolutely known, it is possible to get the slope of the line with very great accuracy.

(*To be continued.*)

CENTRAL STATION CONSTRUCTION.*

BY J. A. POWERS.

There are two ways of constructing a central station for electric lighting each of which has its special object. They may be defined as the speculative and the investment plans. The first has as its legitimate, or, rather, its illegitimate end, the sale of the plant to some unfortunate, perhaps unwilling, capitalist, by fair means or foul. We may consider as fair means the not uncommon method of selling a small portion of the stock, perhaps just enough to pay for the apparatus, on the strength of a showy exhibition in the hands of an expert, who uses all the tricks of the trade to persuade his lambs that his system will produce double the light with half the power of any other, and the other customary arguments.

The foul means is the border ruffian money-or-your-life policy, which enters a territory already sufficiently well served, not for fair competition, but to make money by being bought out.

The electric light business is rapidly emerging from the border ruffian and blackmailing stage, and, as we may shortly expect these methods to be relegated to their proper realm with other things dead and dishonourable, with the growth of popular knowledge of electrical matters, we will leave them, and proceed to the more legitimate methods, which I hope you will all pursue.

"The fool doth think he is wise, but the wise man knows himself to be a fool," said the master of all writers, and that I may be saved entering the first class in your presence, I here confess to many and grievous mistakes in our own central station construction, to which this paper owes its being, for that I may hope to save some of you part of my errors is my only excuse for appearing before you.

Let us, then, drop speculation as a thing of the past in our business, and make our object the construction of such work as shall produce, in the sober judgment of every business man among you, the best results in economy of labour, supplies and power, with the least expenditure for interest, taxes, insurance and repairs.

In all manufacturing enterprises of the day one tendency is unmistakably felt. It is the direction of thorough work. To succeed in any established business one must have substantial buildings, the best improved machinery, the best site for obtaining necessary supplies at their cheapest. Electric lighting to-day has risen from the slough of speculation and stands side by side with other great manufacturing enterprises in importance. Not less than sixty million of dollars are invested in lighting plants alone, and in the entire field probably not less than double that sum. Has not the time come when the same laws of strict economy which obtain in other large enterprises should govern central station construction?

Let us carefully consider our problem, plan cautiously, and expend liberally in the directions which indicate the best results. It is evident, however, that we should not expend without limit. Where shall we draw the line? I believe we are safe in expending every dollar which is sure of saving 10 per cent. interest on its investment, provided we have it to spend. The only danger in the path seems to be the chance of such improvements as shall throw aside our present method of producing electricity. Let us for a moment consider the possibilities in this direction. The best dynamos will to day, in ordinary practice, convert 80 to 85 per cent of the power furnished them into an equivalent of electricity. Clearly there can be but small improvement here. Coal or similar fuel is the common source of power to-day, and seems likely to remain so. The best steam plants give one horse-power hour for about 1½lb. of coal. The actual energy stored in that 1½lb. of coal would give about seven horse-power hours if it could be converted into power without loss; or, in other words, the best steam plants of to day have an efficiency of about 13 per cent.

Prof. Houston remarked at the last convention of the National Electric Light Association that the field where lies the greatest chance for improvement is in the direction of thermo-electricity, the conversion of heat into electricity without the intervention of power. This is most certainly so; for if a process can be discovered which will have a reasonable efficiency, say 25 per cent, electric motors must soon supersede steam engines for power. The nature of the losses connected with the conversion of heat into other forms of energy does not, however, give much encouragement in this direction. The nature of such losses is in the diffusion of heat by conduction and radiation, which has always proved most difficult of control. If a process of simple conversion, without the attendant development of heat, can be devised, the chances of a good efficiency would be much improved, but where heat exists there is radiation, and where radiation is there will be serious loss. How serious we can only judge from our experience with the steam and other heat engines. It is probable that we are safe in investments in our expensive steam plants, at least to the extent of the life of these plants. Let us then return to our subject proper. The first matter of importance to be decided in establishing an electric light station is its location. The necessary qualifications for location may be classed about as follows:—

* Paper read before the American Institute of Electrical Engineers, May 18th, 1887.

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1st. A dry soil—a gravelly soil which will easily leach away the runnings from small drips or leaks, is preferable, next to solid rock. If located near a river, a wide margin of safety from flood should be allowed.

2nd. If practicable, a location near a plentiful water supply should be chosen. Condensation of either high or low pressure engines is desirable in every way, and requires a large water supply.

3rd. Nearness to the coal supply. If possible, locate near a navigable stream, so as to secure cheapness of handling coal and a plentiful supply of water. If not near navigable water, get a location on a railroad switch, and, if possible, near the water supply. If the two conditions cannot be fulfilled, you may make your choice between them, remembering that each additional handling of coal will cost about 10 cents per ton, and extra haul about 10 cents per 1,000ft., and, on the other hand, that condensing your engines will probably save between 15 per cent. and 25 per cent. of your coal expense. The pressing necessity for locating near the lighting field has largely passed away with the introduction of long-distance systems of incandescent lighting.

Having determined on a location, the character of building to be erected must next be considered. The most important single condition essential to the success of the electric light business is continuous and reliable service to customers. The most disastrous calamity which can befall an electric lighting business is the destruction of its central station. The first thing necessary to prevent such a calamity is a building practically fireproof, and I believe a brick building best fulfils these conditions. Let the walls be bare, make all floors double planked and supported on iron beams, use no wood ceiling, however seductive it may be in improving the appearance of your station; leave as few openings as possible through the floors; have a nearly flat roof with fire walls projecting above, and the building will be as nearly fireproof as it can be, and at the same time fulfil the other essential conditions of insulation, and a reasonable expenditure of capital. Before leaving the matter of fire protection, let me strongly advocate the use of some good automatic sprinkler, except in the dynamo room, and especially in parts of the building unoccupied during portions of the day. A stand pipe connected with your spare pump with nozzles on each floor, a few lengths of mill hose, a cask or two set in convenient places and kept filled with water and a few fire pails near are cheaply provided, and the improvement in insurance rates will soon pay for them. At Troy the reduction of rates has paid for the entire fire outfit in the saving in one year's premiums.

Before we design our station further, let me remark that the old adage that "cleanliness is next to godliness" would be a most wholesome motto for the electric light business. Dirt begets dirt, and with electrical apparatus it is by far the most fruitful source of short circuits, grounds, and consequently of burned armatures and disordered apparatus generally. Let us, then, so arrange our station that that most fruitful source of dirt, our boiler house, may give as little trouble as possible. Putting the boilers in the cellar and the engines and dynamos on the floor above is probably the worst possible arrangement next to putting all in the same room, since every opening in the floor conveys a blast of hot air, laden with coal dust and ashes. The correct method is to separate boiler and engine rooms by a fire wall and make the only opening between through a room or passage through which a strong draft of air is always passing. This we effect at Troy by means of an air shaft 6ft. by 8ft., which also serves as a wire tower, and in which wash sinks, &c., are also constructed. The doors leading in both directions are kept shut by heavy springs, and when opened the strong draft carries all dust, smells, &c., up the chimney. This shaft is carried above the roof and the wires are carried out between the louvres of the blinds. One thing do not forget. Arrange a cellar or basement under your dynamo and engine room floor about six feet deep. You will find it infinitely convenient in connecting small pipes, &c., to the under side of the floor.

Make your dynamo room not less than ten feet high for the comfort of your men, and arrange the windows to open clear up to the ceiling, as that is where the hot air will go to escape. You may also put your windows six feet above the floor, and you will save annoyance from spectators and your men will not have so much looking to do.

The boiler house should be light in construction, having an iron roof with some outside covering, such as asphalte, to prevent sweating in cold weather. The boiler fronts should, of course, face either on an open lot or a street to facilitate handling boilers, and for the same reason the front of the boiler house should be easily removable. The floor should be of concrete not less than a foot in thickness, made of the best Portland cement, mixed about one part cement, three parts sharp sand, three parts stone, broken to pass 1½in. ring. On this may be laid a floor of flags or arch brick laid on edge. No floor of cement or of ordinary brick will stand wear.

Going back to our main building, I will follow more particularly the line of work adopted at Troy. Our lot measures 50ft. by 13.ft, and the problem was to develop on that space a station of a maximum capacity of 500 horse-power effective. The lot was occupied by a mere shed covering two 80 horse-power boilers located almost exactly in the middle of the lot; one 150 horse-power compound engine just beside the boiler, belted to 48ft. of jack shaft lying parallel with the length of lot, and 2ft. 6in. above the floor, the dynamos lying each side of the shaft, the pull of the belts being nearly balanced.

The new station was laid out in a dynamo room 50 by 90, and boiler house 40 by 50ft., arranged for a battery of four boilers 72in. by 17ft., stack 13ft. square at ground, and 125ft. above the grates; wire tower in corner between dynamo room and boiler house projecting into the latter. As originally laid out, the engine stood in the new dynamo room close beside the fire wall now separating engine and boiler rooms, and the boilers further out in the dynamo room. It was decided to build the unoccupied end of the dynamo room, put in engine power connected with the old boiler, shift the station, abandon the old engine temporarily, build the rest of the new station over the old, put in new boilers, then connect them and disconnect the old boilers, remove the old boilers, and finish the inside of the building. The company changed hands on May 23, 1885, and on September 1st the old station was shut down at midnight, and the dynamos shifted to the finished part of the new building, and at six the following evening the station was in full operation in its new quarters. The plant then comprised about 600 Weston incandescent lights and some 20 arc lights. The remainder of the work was merely a question of time, and the station was first operated on its new boilers on December 17, 1885. At the same time about fifteen miles of pole lines were constructed, and some thirty miles of wire strung for the city contract of 130 lights.

The general construction of the Troy station is believed to cover the average conditions met with in central station construction, and is therefore particularised. In the arrangement of dynamos and engines we desired to attain the best economical results in the following items:

1st. Best average economy in coal.
2nd. Best average economy in transmission of power to its work.
3rd. Best economy of attendance.
4th. Best economy of oil, waste, &c. Our customers required a day service, and we had to take this into account in our selection of engines for power, and in their arrangement.

These conditions were to be borne in mind in the selection of our engines, and, in addition, the most important condition of reliability. Compound engines offered us the best coal economy, with maximum load, but had the disadvantage of poor economy with light loads. Corliss engines would occupy too much room, and both required shafting and counters to speed up, and would have forced us to use the second floor for dynamos, with the attending disadvantages of extra help and upright belting. We finally decided on using the best type of high speed engines, and purchased three engines of 9 by 14 cylinder, each belted to a jack-shaft 16ft. long, and each driving four 110-light incandescent dynamos, belted in pairs from opposite sides of the shaft. The lengths were arranged to be coupled by friction clutches. This arrangement gave us a very uniform rate of coal economy, though not a very high one. The arrangement of belting made the shaft friction very small. The old compound was set to work on its proper duty of driving a fixed load of city lights.

The relative merits of compound Corliss or high-speed engines are well understood, and the circumstances must in every case decide the type of engine proper to be used.

Where the maximum of output is required from a small space high speed becomes a necessity. Where the load is very variable a number of smaller engines will give as good average coal economy as a single larger engine, with less chance of a complete failure. Where the load is heavy and constant, a pair of large engines will give the best economical results and at the same time cover the possibility of a complete breakdown. The new triple expansion engines, which are rapidly replacing all others in ocean and lake steamers on account of their wonderful coal economy, will probably displace all others in the field.

Condensing high speed engines have not met with much favour, but we find at Troy that our "straight-line" engines work quite as quietly under 28 inches vacuum as without, and that the coal economy is considerably improved, probably from 15 to 20 per cent. on the engines condensed. They have also the advantage of giving us much more power for cases of emergency.

As to boilers, I am strongly in favour of boilers of large size; ours measure 60in. × 17ft., and are of Nashua "Indian head" steel, 7-16th shell, ½in. head, and have 136 3in. tubes. The dimensions of the tubes 3in. × 17ft. would be out of all proportions for ordinary drafts, but our stack 125ft. above the grates gives us ample draft, and the small tubes a great evaporating surface, and consequently a better evaporation. I am afraid I shall be considered a little unsound of mind when I state that with these boilers we are able, and do, evaporate with a mixture of one part bituminous to two of yard pea and dust nine pounds of water per pound of coal, and with ordinary buckwheat coal ten pounds of coal, feed water at 200 degrees. But such is the case, as I shall be happy to show any one visiting us. This is not pounds of combustible, but of coal. I have always found the ashes to cost just as much per ton as the fuel part of the coal, and therefore consider that they have no place in the relation of evaporation per dollar. We keep a daily and nightly record of our evaporation by a Worthington meter, which is on the boiler feed, and let me say that the bad reputation for veracity of meters in general will not apply to our meter, as repeated tests show a nearly constant error of 2 per cent. low.

For boiler feeds provide a reliable injector in addition to feed pump, which latter should always be used in connection with a good heater. An extra feed pump may be connected as a fire pump, and should be used regularly for some such service as washing out boilers, to ensure its being in good order. Attention to surface and bottom flues is, of course, a daily duty. As to fittings use some one kind of valve; get a good kind and stick to it. Price should have no place in the first choice of valves. Get a good one with removable seats and discs and you will save a world of trouble and a deal—not an electric light deal—of money in a few years time. Let me remark that everything we have in bottom blow offs has failed except plain plug valves. The failure seems to come from scale, which will stick under the gates and seats, and bend them out of shape when closed. An extra large valve in the blow-off discharge is desirable in case of a failure of a blow-off valve.

In piping of all kinds discard elbows and use only T's. You will frequently save taking down an entire line of pipe to make some connection by so doing, and the T's are most convenient for examining and cleaning the pipes. You should also obtain all your fittings and pipe of one party, to ensure good fits. Threading tools are seldom alike, and a small variation will give endless trouble with leaks.

Cover all steam pipes, and remember in choosing a covering that it is not the material which you cover with which makes the non-conductors, but the confined air spaces in the same. Get air spaces, and get them so

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arranged that the air cannot circulate between hot and cold surfaces. Remember also that you can tell nothing by the feeling of the outside of a covering about its effectiveness. Sensations of heat and cold are intensified by the conducting capacity of the object touched. A piece of metal attached to a steam covering till hot will convince you of this. It can be no warmer than the covering, but it feels so.

In touching on the electrical apparatus I feel that I am treading on delicate ground, and I shall try and step accordingly. The principal elements of ordinary wear in dynamos are :—

(1) Burned coils in the armature ; (2) wear of brushes ; (3) wear of commutator ; (4) wear of boxes or journals.

In regard to burned armatures I will say that judgment should be exercised in the choice of a system as to the liability of such an accident, and this being determined choose a machine whose armature is most readily repaired. Gramme and similar ring armatures are probably the most easily repaired. Siemens armatures and all armatures with lapped coils must go to the factory for a good job.

As to brushes, the cheapest by far, both in first cost and wear, are the single leaf, split brush. Multiple brushes are usually used in commutators with many segments, and there seems to be some relation between the number of segments and wear of brushes

Commutators of many segments are less desirable than those of few. The segments can usually only be changed by putting on a new commutator and they seldom wear true. The segments on commutators of fewer bars are usually arranged to be easily removed and can then be turned up and replaced.

Plain babbited boxes or bronze bushings are about on a par for convenience in renewal. Bronze has the advantage of not being liable to melt out and cause a shut down, and a little patience will almost always succeed in cooling them down. For belting probably nothing is better than double pasted leather belts if well made. For large belts a few rivets must be put in.

Arc lamps should be devoid of glycerine, and not easily shaken out of adjustment. The lighter and smaller lamps are the better for handling. Arrange all inside wiring of some first-class high insulation wire, especially on high tension circuits.

In the Keystone station in Philadelphia I first saw oil conducted to each machine oiler and cylinder cup in pipes. I heartily approve this system as a saving both of oil and waste.

In conclusion, I will suggest two rules to govern central station construction.

1. Expend every dollar, which will return 10 per cent. on its investment in addition to maintaining itself, including, of course, interest, taxes and wear and tear.

2. After carefully investigating, estimating and planning out the capacity of your station, make a large guess as to what you require, and multiply by two.

COMPANIES' MEETINGS & REPORTS.

The Consolidated Telephone Construction and Maintenance Company (Limited).

An extraordinary general meeting of this Company was held yesterday at the offices of the Telephone Company of Austria, 53, New Broad-street, to confirm the following special resolution passed at the extraordinary general meeting, held on the 2nd inst., at the City Terminus Hotel :—

"That the capital of the Company be reduced from £243,787. 10s. divided into 224,850 shares of 15s. each and 75,150 shares of £1 each, to £232,545 divided into 224,850 shares of 14s. each, and 75,150 shares of £1 each, and that such reduction be effected by returning to the holders of the 224,850 shares that have been issued paid-up capital to the extent of 1s. per share, and by reducing the nominal amount of such 224,850 shares to 14s. each."

Mr. C. L. W. FitzGerald presided, and was supported by all the other members of the Board.

The SECRETARY (Mr. Chas. Curtoys) having read the notice convening the meeting, and the minutes of the ordinary and extraordinary meetings, the latter being confirmed and signed by the Chairman as correctly entered,

The CHAIRMAN, in moving the confirmation of the foregoing resolution, remarked that he need say very little on the subject to which it had reference with the exception that, should it be confirmed, the Directors would at once take steps to get the Court to permit them to return the 1s. to the shareholders. It was impossible for him to say how long time the proceeding would take, but it would be carried into effect as quickly as possible.

Sir ALEXANDER ARMSTRONG, K.C.B., seconded the motion, which was unanimously agreed to, and the proceedings terminated,

South of England Telephone Company (Limited).

Report of the Directors for the twelve months ended 30th April, to be presented to the shareholders at the third ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Tuesday, the 28th inst., at one o'clock :—

During the past year the sum of £16,077. 9s. 5d. has been expended on account of capital, making a total of £27,926. 19s. 11d. The revenue account shows a gross income of £7,584. 15s. 8d., and a net credit balance of £1,059. 11s. 5d., making, with the sum of £727. 3s. 7d. brought forward from last year, an available balance of £1,786. 15s., from which has to be deducted £728. 6s. for preference dividend, leaving a balance of £1,058. 9s., which it is proposed to carry forward. The heavy snowstorm of the 26th December last, which was immediately followed by very strong winds, had a most disastrous effect upon the Company's wires ; the damage, however, was fortunately confined to the northern districts. The entire expenses attending the reconstruction of the lines have been charged to revenue account. In carrying out the new work care has been taken to obviate, as far as possible, a recurrence of a similar disaster. During the past year trunk lines have been run as follows :—Norwich to Great Yarmouth, Northampton to Wellingborough, Chatham to Maidstone, Dover to Folkestone. A trunk line between Margate and Ramsgate is in process of construction, and arrangements are also being made for connecting Brighton and Worthing, and Brighton, Lewes and Eastbourne. The growth of the exchange and private line business may be considered favourable, as shown by the following statement :—

	Exchange Subscribers.	Private Line Renters.
April 30th, 1886	687	248
April 30th, 1887	1,130	348
Increase	443	100

Telephone exchanges are now open at the following places :—Brighton, Cambridge, Chatham, Dover, Eastbourne, Folkestone, Great Yarmouth, Hastings and St. Leonards, Ipswich, King's Lynn, Luton, Maidstone, Margate, Northampton, Norwich, Oxford, Peterboro', Ramsgate, Reading. Mr. D. O. Bateson retires from the Board by rotation, and, being eligible, offers himself for re-election. The shareholders' auditor, Mr. J. Weise, retires, and is eligible for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 17th inst. amounted to £4,663.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.—The coupons due on July 1 on this company's Five per Cent. Mortgage Debentures will be paid by Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C. Coupons should be left three clear days for examination.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 17th inst. amounted to £3,841, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended the 15th inst. are £2,785, as compared with £2,452 in the corresponding period of 1886.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 22.		BUSINESS DONE WEEK ENDING JUNE 22. Highest.		Lowest.	
Anglo-American	35,	36		35		—
Do. Preferred	57,	58		57½		57
Do. Deferred	13½,	14½		13 15-16		13 13-16
Brazilian Submarine	11¼,	11¾		11¾		11¼
Cuba	12,	12½		—		—
Do. Preference	18,	19		—		—
Direct Spanish	2¾,	3		—		—
Do. Preference	7½,	8½		—		—
Direct United States Cable	8¾,	9¼		9		—
Eastern Telegraph	10⅜,	10⅝		10¾		10⅜
Do. 6 per Cent. Preference	14,	14½		14½		—
Do. 5 per Cent. Debentures, 1899	107,	110		—		—
Eastern Extension	11⅜,	11¾		11½		1.⅜
German Union	10½,	11		—		—
Globe Telegraph and Trust	5⅜,	5½		5 9-16		5 5-16
Do. Preference	13,	13½		13 3-16		12 15-16
Great Northern	13½,	14		—		—
Indo-European	34,	35		—		—
Reuter's	7⅜,	8½		7½		—
Submarine	180,	190		—		—
West India and Panama	⅝,	¾		—		—
Do. 1st Preference	8½,	9		—		—
Western Brazilian	8,	8½		8½		8½
Western Union 7 per Cent. 1st Mortgage	120,	125		—		—
Do. 6 per Cent. Sterling Bonds	104,	107		—		—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½		—		— xd.
Oriental	⅛,	⅜		—		—
United Telephone	12½,	13½		12½		12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅝,	3½		—		—
Do. (fully paid)	4,	4½		—		—
Swan	1½,	1½		—		—
Maxim Weston	3-16,	5-16		—		—

MISCELLANEOUS.

Telegraph Construction	36,	37		36⅜		36½
India Rubber, Gutta Percha, and Telegraph Works	23,	24		23½		—

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NOTES.

THE UNITED TELEPHONE COMPANY.—The annual report of this company will be found in another column.

NAPLES.—The Municipality Council of Naples has passed a resolution making the electric light compulsory in the theatres of that town.

THE TECHNICAL COLLEGE, FINSBURY.—We have been requested to make known that Friday, July 15th, has been fixed for the date of the annual students' *conversazione* of the City and Guilds Technical College at Finsbury.

TELEGRAPH EXTENSION IN THE WEST INDIES.—The Madrid *Gazette*, of June 26th, contains a royal decree granting the D José Rafael Vizcarrando the right to establish and work a telegraph cable between the islands of Cuba and Hayti.

THE ROYAL SOCIETY.—At the annual meeting of the Royal Society just held at Burlington House the following, amongst others, were elected Fellows: Prof. J. A. Ewing, B.Sc.; Prof. G. Forbes, M.A.; Prof. J. Milne, F.G.S.; Prof. Oliver J. Lodge, D.Sc.

THE PHYSICAL SOCIETY.—The abstract of the proceedings of the Physical Society, which will be found in another column, contains some very interesting notes by Profs. Ayrton and Perry on "Magnetic Resistance" and on a "New Ammeter and Voltmeter."

OBITUARY.—The death is announced of Professor Cecchi, of Florence. Professor Cecchi was the author of an important work on seismology, and of various papers on electrical subjects. He also devised an arc lamp, an electro-motor, and an induction machine.

THE ESCURIAL.—The famous palace and monastery of the Escurial has recently been supplied with a small installation of arc lamps. The chapel is lit with eight arcs of 4,000 candles, and eight more of the same size are placed upon the summit of the loftiest tower.

THE PARIS-ROUEN TELEPHONE LINE.—This line was opened for public service on the 25th inst. The charge is 1f. for five minutes' conversation. At present communication is only open between the Bourses, and the charge of 1f. is payable whether the individual wanted is or is not present when asked for.

PERSONAL.—It has been stated this week in certain quarters that Mr. Crompton is seriously ill. We are, however, glad to be able to state that the rumour has no foundation; in fact, Mr. Crompton is in his usual state of health, but is at present in Vienna superintending the carrying out of some important work in that city.

MEXICO.—The authorities of the city of Mexico have renewed the contract with the electric light company for a term of three years on the following basis:—The streets are to be lighted by the company 2,750 hours per annum; for each lamp the company is to receive $37.50 per annum, for each electric arc of not less than 2,000 candle-power $31.25. per month.

SEVEN HUNDRED AND NINETY SHEEP KILLED BY LIGHTNING.—A Reuter's telegram from Cape Town states that on the 17th of May last, at the farm of Biesjesdam, near Victoria West, a small house around which a flock of sheep were sheltering was struck by lightning, which shattered the gable of the building to its foundation, and killed no less than 790 out of the flock of 1,430 sheep.

THE VAN RYSSELBERGHE SYSTEM IN JAPAN.—Van Ryssel-berghe's system of simultaneous telegraphy and telephony has been tried in Japan between Takaraki and Jokogawa. Professor J. Fujioka, of the College of Engineers at Tokio, who has been instructed to examine the system on behalf of the Japanese Government, has reported that the method is well adapted for use upon the principal telegraph lines of the country.

SALE OF ELECTRICAL PLANT.—A large quantity of electrical and engineering plant, the stock of Messrs. Corner, Allan and Co. (Limited), Wandsworth Bridge Wharf, Fulham, was sold by auction on the 23rd and 24th ult, by Messrs. Wheatley Kirk, Price and Goulty, of 52, Queen Victoria-street. Amongst the electrical apparatus were a number of dynamos of the Crompton, Bürgin, Gramme, Oppermann, and Ball types, which realised average prices.

BRITISH AND AMERICAN UNITS OF LENGTH.—United States and British measures of length are commonly considered to be the same; but, in fact, the British are shorter than the United States by about 1 part in 17,230, or 3·677 inches in a mile.

U.S. inch = ·025401 metre.	British inch = ·0253995 metre.
U.S. foot = ·30481 ,,	British foot = ·304794 ,,
U.S. yard = ·914430 ,,	British yard = ·914382 ,,

THE ELECTROLYTIC PRODUCTION OF ALUMINIUM.—It is announced that Dr. Kleiner, of Zurich, has succeeded in obtaining aluminium by the direct electrolysis of cryolite, a mineral consisting of a compound of sodium and aluminium fluorides, $3\,NaF + AlF_3$. But Kleiner's method only yields at present about $3\frac{1}{2}$ grammes per horse-power hour, while by the Cowles process at least three times that quantity is obtained. A company has recently been formed in Belgium to work the latter process.

THE JUBILEE BALL AT THE GUILDHALL.—On the occasion of the Jubilee Ball at the Guildhall on the 28th inst. the temporary crush room in the Guildhall courtyard, which was made of a wooden framing, was lit throughout by Messrs. Woodhouse and Rawson with about 80 incandescent lamps of 10 and 20 candle-power. These were all fitted with elegant shades suspended with silk cord from the roof, the colours being chosen with very good taste to harmonise with the character of the decorations. E.P.S. accumulators were used to supply the current.

THE CITY AND GUILDS OF LONDON INSTITUTE.—On Monday afternoon, July 4th, after the laying of the foundation stone of the Imperial Institute by Her Majesty the Queen, the attendance of the visitors is requested at an inspection of the Central Institution in the Exhibition-road. The several laboratories and workshops of the Institution will be open to view, and there will be an exhibition of the work executed by the students of some of the technological classes that have been established in different parts of the kingdon in connection with the Institute.

"ELECTRICAL PLANT."—*Electrical Plant*, a monthly register of new and second-hand electrical plant, apparatus, fittings, &c., is the title of a new monthly trade circular issued by Messrs. Wheatley Kirk, Price and Goulty, the well-known auctioneers. We believe that this circular will supply a want which has long been felt in affording a ready means of ascertaining the whereabouts of second-hand electrical plant, and we wish the publishers every success in their venture. The first number has evidently been got up with considerable care, and contains a very extensive list of electrical apparatus of all kinds.

TELEPHONY AND THEATRES.—The Telephone Company at Rome have been devoting their attention to perfecting arrangements for transmitting opera music by telephone. The best

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results have been attained by means of a microphone, of which the contacts are placed in the focus of a parabolic reflector. Instead of being placed at the front of the stage, it is found preferable to hang the transmitters under the columns of the first row of boxes. These trials have been made at the Théâtre National during the representation of *Puritani*, and it is said that the transmission both of solos, choruses, and orchestration has attained an astonishing degree of clearness and accuracy.

Curious Manifestation of Electric Action.—In a printing office at Mayence which has been paved with asphalte some extraordinary electrical effects have been manifested during the late spell of dry weather. The paper as it passed through the machines is described as giving off a rapid succession of brilliant sparks. On presenting the hand sparks several inches in length could be obtained from the framework of the machines. At one time the discharges were so violent that the men refused to go on with their work. All this is the more remarkable because paper is usually damped before being printed on. However, the *Elektrotechnischer Anzeiger* is our authority for the story.

Admiralty Contracts for Dynamos and Engines.—The Admiralty have lately contracted for 35 sets of dynamos and engines of various sizes and types. In another column will be found the full text of the specification issued by the Director of Naval Stores. It will be observed that the limitation as to the rise of temperature permitted in the dynamos under full load is very stringent. No doubt it is found useful to stipulate for a very high factor of safety in this direction, so as to secure a machine which may be trusted to work in any climate, and, if necessary, at an output considerably beyond the normal. At the same time, we are rather inclined to doubt whether 20°F. is not an almost impracticable limit for the increase of temperature.

Query: the Discovery of a New Motive Power?—In *La France* of June 13th, 1887, there appeared a paragraph of the usual stock-in-trade character of the non-technical press when writing on anything scientific. "M. Maiche," we are told, "has invented a new machine by means of which we shall obtain the electric light at a price less than half what it costs to-day. This machine, based upon principles entirely novel, leaves far in the rear everything previously known. It is a true revolution in the art of electric lighting." It is manifest that nothing but the discovery of a new motive-power can possibly justify the statement as to the reduction of cost, and we have therefore only to remark that the paragraph is couched in altogether too modest terms.

Self-Exciting Alternating Current Dynamos.—The possibility of causing an alternating current machine to excite its own field by commutating a portion of the armature current probably did not escape the observation of the earlier dynamo makers. There is, however, some practical difficulty in the way of carrying out the arrangement, owing to the necessity for a very accurate adjustment of the brushes to avoid sparking at the commutator. In the Zipernouski-Déri machine the proper length of the brush and its exact position are carefully marked by the constructors. In case of sparking it is worth noting that if the flashes are long and brilliant the brushes require to be moved against the direction of rotation, while if short and not very vivid the adjustment must be made in the other direction.

The Variation of the Resistance of Lamp Filaments.—Some experiments, communicated to the American Institute of Electrical Engineers by Prof. W. A. Anthony, serve to show that the resistance of an incandescent lamp filament does not decrease continually as the difference of potential at the terminals increases. After a certain point the resistance passes through a minimum value, and again increases. The point of minimum resistance, however, varies widely even with lamps of the same type. Prof. Elihu Thompson remarked that he had noticed the same fact, and added that when incandescent lamps are placed in series and traversed by a constant current he had found that their resistance tended at first to decrease, but after a certain time it again augmented, and this phase continued until the temperature became sufficiently high to destroy the lamp.

"Electric Meteorology."—Mr. G. A. Rowell, of Oxford, sends us a pamphlet with the above title, in which he discusses the cause of the changes in magnetic declination. He adduces evidence to show that the European and American magnetic poles are coincident with the centres of greatest cold for the two continents. Hence he attributes the shifting of the magnetic poles to the same series of astronomic and geologic causes which produce the secular changes in climate. This theory leads to the uncomfortable conclusion that as the magnetic declination in this country continues to decrease, so our winters will increase in length and severity. Without laying undue stress on the point, the author is certainly able to appeal to our recent melancholy experiences as an argument upon his side. If our readers will refer to page 252 of our previous volume they will find further information, not without interest, concerning Mr. Rowell and his scientific career.

The Indo-European Telegraph Service.—The *Homeward Mail* contains the following paragraph:—"Mr. Henniker Heaton, as the censor of Posts and Telegraphs, may be interested to learn that Colonel Holland, of the Indo-European Telegraph Company, recently stated that if the management of the Indian Government lines were equal to that of the company's, a message from India should arrive in England in about forty to forty-one minutes, instead of, on an average, upwards of two hours, as was the case at present, and that this was a matter which the Government of India ought certainly to be able to remedy." On the other hand the *Englishman* publishes the following short paragraph, which is perhaps intended as a semi-official answer to the above:—"The average time occupied in the transmission of messages from Calcutta to the United Kingdom by the Indo European Telegraph Company during the last fortnight in May was one hour thirty-nine minutes."

Lincoln.—On the night of the Jubilee celebration the great tower of Lincoln Cathedral, which is 271ft. in height, was illuminated by 32 arc lamps, of 200 candle-power, or in all 64,000 candles. Four of these lamps were placed on the top of the four pinnacles, at a height of 40ft. above the summit of the tower itself. Lincoln Cathedral stands upon a hill some 300ft. high, so that the total height of the lamps above the level of the flat country around the city was between 500ft. and 600ft. The effect of the illumination was very fine, the lamps appearing like a brilliant crown in the sky; and, as may be supposed, the light was seen from very great distances. The installation was carried out by Messrs. Robey and Co., the well-known engineers, of Lincoln, who employed on this occasion the plant which has been used for the electric lighting of their own works for the past seven years. We are indebted to Messrs. Robey and Co. for a very fine photograph of the cathedral, showing the lamps in place upon the summit of the tower, and the method adopted for supporting the four lamps upon the pinnacles. We learn also that the light was seen as far north as Doncaster and York, southward as far as

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Boston, Peterborough, and Ely, and far into the midland counties.

On the Relation between the Peltier Effect and the Contact Difference of Potential of Two Metals.—The contact difference of potential between any two metals depends solely upon the nature of the metals chosen, and upon their temperature. Similarly, the Peltier effect between two metals (or the liberation of heat which takes place when a current of electricity passes in one direction from one metal to another) depends solely for a given current upon the nature of the metals, and upon their temperature. It has therefore been supposed that a relation of direct proportionality existed between the contact difference of potential of two metals and their coefficient for the Peltier effect. The experiments of M. Pellat have, however, cast very considerable doubt upon the truth of this assumption. M. Duhem has also recently investigated the subject, and in a note read before the French Academy on June 6th he enunciates the following theorems:—(1) The coefficient of the Peltier effect is proportional to the product of the absolute temperature and of the first differential coefficient of the contact potential with respect to the temperature. (2) The electromotive force of a thermo-electric couple is equal (in electrostatic units) to the excess of the contact potential between the two metals at the cold junction over the contact potential at the hot junction.

Electric Shocks.—Some impromptu experiments upon the physiological effects of the electric currents, or, more properly, difference of potential, have recently been related by Dr. Zacharias, of Berlin. On one occasion when walking along the electric tramway at the mines of Hohenzollern the Doctor happened to slip, and in falling caught hold of the conductor, which was at a potential of 300 volts above the rails. This, however, "made little impression upon him." Another time, having incautiously taken hold of the framework of an arc lamp supplied with alternating currents at a potential of 200 volts he was unable to leave go until someone came to the rescue by lifting him off the ground. On this occasion the soil was very damp; in dry weather he found that little or no inconvenience was experienced. The most painful experience which Dr. Zacharias has hitherto encountered occurred in an attempt to disconnect a dynamometer under a potential of 1,500 volts. On this occasion a severe and painful shock was felt through both arms; but still no serious results ensued. Stories of this character are, however, told by most electricians who have to do with dynamos, and although, happily, accidents of a fatal or even of a serious character are so rare as to be almost unknown, yet the immunity of the past should not be permitted to encourage any laxity or foolhardiness in dealing with high tension machines.

Dun's Portable Battery.—A battery specially designed by Herr Dun for call bells and telephones and for medical purposes has been for some time in use in Germany, and is said to have given considerable satisfaction. The elements are zinc and carbon. The carbon, in the form of a hollow cylinder, is placed within the zinc, and is bored full of holes, which are filled with fragments of permanganate of potassium. The cylinder is wrapped on the outside with parchment paper, and is then filled with caustic soda in which the permanganate gradually dissolves. A piece of parchment paper is placed over the top of the cylinder, the zinc (also in the form of a cylinder) is placed in position outside, and the glass or porcelain vessel is then nearly filled with a hot solution of caustic soda to which a little starch has been added. This solution is poured in until both cylinders are entirely covered, and the liquid stands an inch or so above the upper surface of the carbon. On cooling the solution forms a gelatinous mass, like the "graphs" of various kinds which were so popular in this country a few years ago. Insulated conducting wires are, of course, led from the plates to suitable terminals. Finally, the outer vessel is filled to the brim with plaster of paris, or, if preferred, with paraffin, which is poured on the top of the starch jelly. By this means the permanganate solution is thoroughly protected from atmospheric action. The internal resistance is said to be low, and so also is the cost of the cell.

The Polarisation of an Electrode by Variation of Surface of Contact with a Liquid.—In the recent and important experiments by M. Pellat on the measurement of contact differences of potential (see *Electrician*, June 3rd, 1887, p. 81), the author made use of the phenomenon discovered by M. Lippmann that when mercury in contact with sulphuric acid forms a part of a closed circuit, containing also a galvanometer (but no battery), a momentary current is set up when the surface of contact between the metal and the acid is either extended or contracted. The experiment is more easily made with mercury than with other metals, but recently M. Knochkoll has observed the same effect with copper in contact with dilute saline solutions, and also with distilled water. The experiments were carried out in the Laboratory of Physical Research of the Sorbonne, and led to the conclusion that, accepting the hypothesis of MM. Lippmann and Pellat (vide *Electrician* loc. cit.), the actual contact E.M.F. of copper with a 2 per cent. solution of sulphate of soda lies between 0·304 volt and 0·348 volt. The experiments were made by the same method as was adopted by M. Pellat—that is to say, the E.M.F. due to an extension of the contact surface was balanced by an external and measurable difference of potential until a change of surface showed no current through the galvanometer. The external difference of potential was interpolated in the circuit by means of non-polarisable electrodes, consisting of copper in a solution of cupric sulphate. These results were brought before the French Academy on the 23rd ult.

Illuminations at Kensington.—Messrs. Crompton and Co. write us as follows:—"Besides the list of special lighting already published by you for the Jubilee celebrations, the Kensington Court Electric Light Company, which is making rapid progress in private house lighting, carried out the following:—A triumphal arch, close to the entrance of Kensington Palace, was brilliantly illuminated with six Crompton arc lamps, of 500 to 1,000 candle-power each. Mr. Hunt's private house, which was gaily decorated, was lighted outside with a powerful Crompton lamp of 4,000 candle-power. (This house has recently been supplied for a permanency with the electric light from the central station.) For Mr. Hall, fishmonger, who has lately introduced the electric light into his shop, a large V R, 16 candle-power, also two statuettes, carrying incandescent lamps of 32 candle-power in each hand. For Mr. Savage, a jeweller, the dates 1837 and 1887 in incandescent lamps of 16 candle-power. The above have had the illuminations continued consecutively from Friday week until Wednesday, the 29th. Besides the above supplied with current from the central station, special illuminations were fixed for Sir Richard Webster, which were driven from his own plant, and Mr. Crompton had his private house supplied with current in the same manner. Messrs. Barclay's bank in Lombard-street was very prettily lit up, the incandescent lamps forming the letters V R showing up to good advantage. There were very few people who had electric light installations of their own, or had command of the current from elsewhere, who omitted to make some pretty and striking device, showing how admirably adapted the electric light is for carrying out illuminations."

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TEMPORARY INSTALLATIONS—JUBILEE AND OTHERWISE.—Messrs. Shippey Bros. send us the following notes:—"The following installations, amongst others, have recently been carried out by Messrs. Shippey Bros.: A 12,000 candle-power arc light plant, 'Brush' system, in the grounds of Captain Hargreaves, The Mount, Bishopstoke. The lighting of the new Tower Gardens, Herne Bay, which were opened on Saturday last, with a 12,000 candle-power Gülcher plant, consisting of six lamps of 2,000 candle-power. The lamps were placed upon scaffold poles 45ft. high in the gardens, which face the sea, and were seen for many miles around the coast. The Jubilee Hall, recently built by Mr. Collard, of Herne Bay, was lighted by sixty low resistance lamps of thirty volts, run two in series, enclosed in specially designed globes, with electro-plated fittings placed at equal distances round the hall, and the centre chandelier studded with numerous silver stars, in which the lamps were embedded, an arrangement which is described as having produced a very pleasing effect. Several two and three light Pieper arc lamp plants were supplied for the occasion of the Jubilee at Goole, Manchester, Blackheath, Belfast, Beltinge, and other places in the United Kingdom. For fancy coloured incandescent lamps, devices, and monograms, the demand has been very great, and many orders had to be refused. A specially-designed device of 300 small 10-volt 5 candle-power lamps, coupled 10 in series, was supplied to a well-known sportsman, mounted on a board covered with crimson velvet, with the following inscription, 'Fifty runs and not out.' This was fixed in front of the house, and run from a 100-volt circuit, above which was the portrait of the Queen, studded round with 50 2-volt light blue fairy lamps, fed from one large E.P.S. accumulator of 60 ampere-hours capacity. A private house in St. Helen's-gardens, Bayswater, was illuminated outside with 40 coloured and opaline incandescent lamps, and also a private residence in St. George's square, Belgravia. About 500 coloured lamps were supplied for the illuminations at Lancaster, Bolton, and Leicester. At Ferdale House, Leamington-gardens, North Kensington, the front windows were all lined with small 8-volt lamps, set in silver rosettes, about 3in. apart, while twelve 50 candle-power lamps lighted the upper portion of the house, being hung from the bay windows."

PARIS.—THE MONTMARTRE CENTRAL LIGHTING STATION.—We briefly chronicled in our last issue the opening of the central lighting station of the Compagnie Française d'Eclairage Electrique in the Rue Drout. This is the first scheme of the kind out of the numbers which have been talked about from time to time which has actually come into existence in Paris, and as such it is certainly a noteworthy event. The plant consists of two engines of 60 horse-power and four Gramme machines of the so-called "*type supérieur*." There are also held in reserve 120 accumulators of sufficient capacity to take the place of one of the dynamos in the event of a breakdown. The supply is maintained night and day. The machines give each 200 volts, and are connected two in parallel, the two pairs serving separate and independent circuits. The mains are, however, laid out upon a system termed "*en boucle*" (or linked), of which we do not remember to have heard before, and which is not clearly described by our French contemporaries. It is said, however, that the arrangement effects a distribution at constant potential at all points, and that the two circuits can be worked either separately or in series, or if desired in parallel, and in the latter case the distribution reverts to the Edison-Hopkinson three-wire system. The conductors are carried overhead, and consist of bare stranded copper wire. They are supported by porcelain insulators, and the wire is coated with india-rubber for some distance on either side of the posts. The station is very dentrally situated for the district to be served, and up to the present only 1,400 lamps are in use in sixteen buildings, so that no especial difficulty has yet been experienced in arranging the conductors. Swan lamps of ten, sixteen, and thirty-two candle-power are employed. The consumers are charged for on the basis of current supplied at the rate of twenty centimes per ampere hour, at 100 volts, or about 1s. 7d. per unit. This is about 10 or 12 per cent. dearer than the price of gas at Paris for equal illumination. The current is measured by Cauderay meters. Some improvements have recently been effected by the Compagnie Française in this meter, chiefly by the substitution of a dynamometer action instead of the permanent magnets hitherto employed. This is undeniably a step in the right direction, and we anticipate that before long more will be heard of the Cauderay meter in our own country. We are glad to learn that since the opening of the station there has been so great an increase in the demand upon the company that it is already in contemplation to increase the capacity of the plant to 6,000 lamps.

LIGHTING OF A NEWSPAPER OFFICE AT IPSWICH.—The office of the *East Anglican Daily Times*, at Ipswich, which has recently been rebuilt at considerable cost, is lighted throughout by electricity. From a special "Jubilee" edition of the paper we take the following account of the installation:—"The necessary machinery and fittings were supplied by Messrs. Paris and Co., electrical engineers, of Gothic Works, Norwich, and fixed under the personal superintendence of Mr. Paris. The electricity is generated by a 150-light dynamo, fixed in a specially constructed apartment in the basement. It is fitted with Messrs. Paris and Scott's new armature winding, an invention by which the resistance of the magnetic field is considerably reduced, and a larger output of electricity is secured than could be obtained with any other machine of a similar size. The dynamo runs at the rate of 800 revs. per minute, and gives an output of 100 amperes at 100 volts. On a recent occasion the machine was thoroughly tested, and it was found that after running eight hours with an average of 87 amperes passing through the armature the latter was not in the slightest heated, thus showing that the strength of the current might be nearly doubled without any material loss. The current is conducted through the building by six different circuits—one for the machine and engine rooms, one for the front offices and passages, two for the composing room, one for the editorial and other rooms on the first floor, and one for the lantern and turret room. Each circuit is governed by a magnetic 'cut-out,' patented by Messrs. Paris and Scott, which can be so arranged that if the strength of the current is increased by the smallest percentage beyond what the lamps are supposed to take the current will be cut off before any injury is done. These 'cut-outs' can also be utilised as switches. The return current is brought back by two separate mains, in which Hedges' fuse is insulated, so that both negative and positive wires are carefully protected. All the fittings here and throughout the building have been fixed according to the rules of the Phœnix Fire Office. The 'cut-outs' are mounted on slate slabs, and the switches on specially manufactured earthenware plates, so that no mechanical arrangement for turning the lights on and off is in immediate contact with the woodwork or brickwork in the building. The machine room is lighted by a number of small lamps placed directly over the printing and folding machines, and covered with green shades, which take the light off the eyes of the workmen, and throw it direct on to the work. In the centre of the room there is a handsome electrolier, with five lights, and a smaller one at each end with three lights each. The lights in the publishing room and front office are arranged to meet the requirements of the departments.

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In the front office the principal illumination is supplied by a seven-light electrolier, fitted with ground glass lamps and ice glass shades, which have a pretty and artistic effect. In addition to these are a number of movable lamps, which can be adjusted to any desired height to suit the convenience of the clerks. The lamps in the passages are fitted with artistic hexagon glass shades. In the composing room there are fifty small lamps, all covered with green shades to deflect the light on to the "cases" and "stones," and to protect the eyes of the compositors. It is in this room, more perhaps than any other, that the advantages of the electric light are apparent. Anyone acquainted with the interior of the composing room of a daily paper must have experienced the stifling sensation which is produced by fifty or sixty gas jets burning all the evening and more than half through the night. The air becomes thoroughly vitiated, and necessarily injurious. By the introduction of the electric light into the composing room it is hoped to secure a healther atmosphere, and the experience up to the present has been more than satisfactory, for after the lights had been burning eight hours there was scarcely a perceptible increase in the temperature of the room. The smaller rooms on this floor are also suitably lighted, and where necessary small electric table lamps are supplied. These lamps can be moved to any part of the room, and when not in use can be fixed as bracket lamps to the wall. Each lamp is governed by a separate switch, so that the light can be turned on or off as required. The handsome wrought-iron lantern on the front of the turret is supplied by a separate current, and is fitted with eighteen lamps, which produce a very brilliant light."

BANQUET TO PROF. TYNDALL.—On Wednesday evening last a large and distinguished company attended a banquet at Willis's Rooms, which was held as a formal recognition of the great services rendered to the cause of scientific progress by Prof. Tyndall on his retirement from the Chair of Natural Philosophy in the Royal Institution. The chair was taken by Prof. Stokes, President of the Royal Society, who had acted as chairman of the organising committee. Among those who had consented to serve on the committee were the Marquis of Salisbury, the Duke of Devonshire, the Duke of Argyll, the Right Hon. J. Inglis, Earl of Rosse, Earl Granville, Sir F. Abel, Prof. Adams, and many others holding distinguished positions in connection with scientific and learned societies, and Mr. J. Norman Lockyer and Mr. A. W. Rücker had acted as honorary secretaries to the committee. Among those who attended the dinner were the Earl of Derby, Earl Bathurst, the Earl of Lytton, Sir F. Leighton, Lord Rayleigh, Lord Thurlow, Sir J. Lubbock, M.P., Sir F. Bramwell, Sir H. Roscoe, M.P., Sir Lyon Playfair, M.P., Prof. J. C. Adams, Prof. Asa Gray, Prof. Flower, A. Geikie, Dr. Frankland, Dr. Debus, W. Crookes, Prof. B. Stewart, Prof. Judd, and General Strachey. The Chairman, in proposing the toast of the evening, dwelt upon the many profound and beautiful investigations of their illustrious guest on some of the most delicate questions of physical science, especially those upon the diathermancy of gases and the effect of aqueous vapour upon solar and terrestrial radiation. He dwelt also upon the unrivalled power of clear exposition, and of the charm of lucidity which has rendered Prof. Tyndall's writings so potent a factor in the spread of scientific teaching. The toast of Prof. Tyndall's health was drunk with great enthusiasm. Prof. Tyndall on rising to respond was received with loud cheers. In the course of a most interesting address, after warmly acknowledging the high compliment paid him, he spoke as follows:—"In 1850, during a flying visit from Germany to England, I stood for the first time in the bright presence of Faraday. In February, 1853, I gave my first Friday evening lecture in the Royal Institution; and three months afterwards, on the motion of Faraday, the old Chair of Natural Philosophy, which had been filled at the beginning of the century by Thomas Young, was restored, and to it I was elected. It causes me genuine pleasure to think that I shall be succeeded in that chair by so true and so eminent a man of science as Lord Rayleigh. It is not my intention to overburden you with egotism to-night; but, casting an earnest glance back upon the past, a few words seem due from me to the memory of one or two of the group of good men, no longer with us, with whom I was so intimately associated. Regarding Faraday, I will confine myself to stating that years have not altered my estimate of the beauty and the nobleness of his character. He was the prince of experimental philosophers; but he was more than this—in every fibre of his mind he was a gentleman. I might point to the industries which affiliate themselves with Faraday's discovery of benzol, and with his discovery of the laws of electrolysis. But I need not go further than the fact that in this our day a noble and powerful profession has been called into existence by his discovery of magneto-electricity. The electric lamps which mildly illuminate our rooms, the foci which flood with light of solar brilliancy our railway stations and public halls, can all be traced back to an ancestral spark so small as to be barely visible. With impatient ardour Faraday refused to pause in his quest of principles to intensify his spark. That work he deliberately left to others, confidently predicting that it would be accomplished. And prompted by motives both natural and laudable, but which had never the slightest influence on Faraday, others have developed his spark into the splendours which now shine in our midst. It would be a handsome Jubilee present, if it were a possible one, to roll up the career of Faraday into portable form, and to offer it to the Queen as the achievement of one of Her Majesty's most devoted subjects during her own reign. Faraday's series of great discoveries, however, began in 1831, which throws his work five or six years too far back. During the rest of his fruitful life he was a loyal son of the Victorian epoch. But, passing beyond the limitations of the individual, what is science as a whole able to offer on the golden wedding of the Queen with her people? A present of the principle of gravitation—a handing over to Her Majesty of the bit and bridle whereby the compelling intellect of Newton brought the solar system under the yoke of physical laws—would surely be a handsome offering. I mention this case of known and conspicuous grandeur in order to fix the value of another generalisation which the science of her reign can proudly offer to the Queen. Quite fit to take rank with the principle of gravitation—more momentous if that be possible—is that law of conservation which combines the energies of the material universe into an organic whole, that law which enables the eye of science to follow the flying shuttles of the universal power, as it weaves what the Earth Spirit in 'Faust' calls 'the living garment of God.' This, then, is the largest flower of the garland which the science of the last fifty years is able to offer to the Queen. The second generalisation is like unto the first in point of importance, though very unlike as regards its reception by the world. For, whereas the principle of conservation with all its far-reaching and, from some points of view, tremendous implications, slid quietly into acceptance, its successor evoked the thunder peals which it is said always accompany the marriage of thought and fact. For a long time the scent of danger was in the air. But the evil odour has passed away; the air is fresher than before; it fills our lungs and purifies our blood; and science in its Jubilee offering to the Queen is able to add to the law of conservation the principle of evolution."

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INCANDESCENT LAMP MANUFACTURE.—XVIII.

BY J. SWINBURNE.

Exhausting Continued.

The valve arrangement in connection with the writer's pumps was found the best for factory work, but for experimental use a slight modification is advisable. This is shown in Fig. 18. An S tube is inserted between the little bulb and the bulb of the pump. The mercury on falling not only leaves enough to seal the valve, but also leaves a little in the bend of the S tube. If there is any water in the pump this shows it immediately, as its vapour has enough tension to prevent the mercury remaining in the bend. If the amount of water vapour is very small, it is left in the small bulb, so that the vacuum in the large bulb is as perfect as possible.

When the vacuum is very good, the mercury is not raised enough to lift the valve every time, but just enough to discharge into the little bulb. When the discharge of from ten to twenty strokes has accumulated in the little bulb the mercury is raised so as to work the valve. The whole discharge of twenty strokes is thus accumulated in a little bubble on the side of the valve tube. As this valve itself is under a pressure of not more than half-an-inch, it represents a vacuum sometimes as high as one in several million, according to the usual measurements of high vacua.

This S tube can be used without the valve, but it must then be made longer, as the attraction of the mercury for itself and its inertia make a longer tube necessary than would be needed to hold against the pressure alone. Care must be taken as to the bore of the S tube; it must not be larger at the point *a* than at *b*, for the attraction of mercury for itself makes it tend to flow towards the larger part of a small tube. Though the S tube for exhausting into a mechanical vacuum was in use by the writer for some time, it was abandoned because when the lamps were nearly finished the shock of the rising mercury against the mercury in the bend often punched out a little piece of glass. When this happened not only was the pump itself broken, but the mercury went round into the phosphoric tube and into the lamps themselves, and the whole had to be replaced. Many other arrangements of valves or their equivalents have been tried, but without getting anything better.

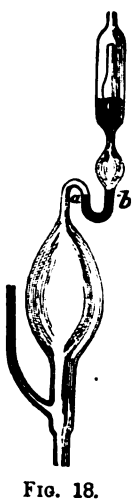

Fig. 18.

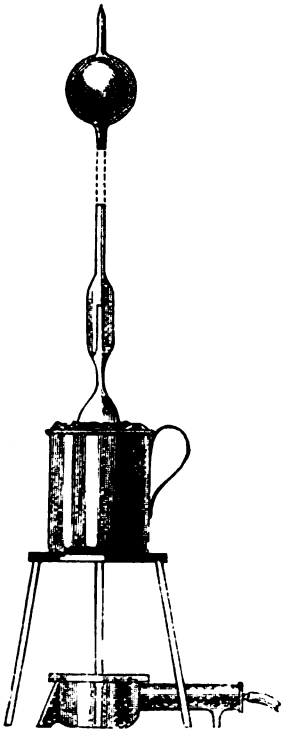

Fig. 19.

It need hardly be remarked that hand-worked taps or valves opening directly into the air are of no use, as not only water vapour, but air itself, will adhere to the surface of the glass under pressure

The phosphoric tubes are rather troublesome. The writer has tried various other drying substances. Sulphuric acid boils, and the vapour goes into the pump; zinc chloride, soda lime, and calcium chloride either do not dry the air enough or themselves give off vapour under the high vacua obtained by the pumps just described. Even phosphoric anhydride itself is sometimes troublesome. When wetted a little after some use it boils slowly. This may be due to its giving off some of the water it has absorbed, or to air coming off the glass underneath it, or the anhydride itself volatilising, or to its containing phosphorous acid. If phosphoric anhydride is very slightly heated in a good vacuum it will be found to volatilise and condense or sublime in the neighbouring tubes.

The writer has tried some experiments with the view of leaving residual vacua of vapours, which are decomposed by the heat of the carbon when the lamp is run, forming a solid, or a vapour of very low tension. As it seemed likely that water vapour formed a large part of the atmosphere in an ordinary incandescent lamp, it was attempted to decompose any vapour that might be left at the same time. The lamps were exhausted, and then filled with carbon disulphide vapour and exhausted again. This was repeated several times.

After each filling with carbon disulphide the lamps were strongly heated, so that the carbon disulphide might decompose any water vapour present. After exhaustion the vacua of the lamps were tested. The lamps were then run and tested again, the idea being that the carbon disulphide would be decomposed into carbon, which would be deposited, and sulphur, which would have a very low vapour tension. There was, however, no apparent difference.

A curious phenomenon was observed. During the exhaustion of the carbon disulphide lamps there were frequent explosions in the pumps. These did not break the pumps, though they made a sharp report. Tyndall observed the same effect in experimenting on carbon disulphide in his researches on absorption of heat by vapours (*Contributions to Molecular Physics*). Not only did these explosions occur without any apparent cause, but the result was a deposit not of sulphur, but of carbon in the form of soot. It would appear that the vapour is so prone to combine with the air that it does so at such a low temperature that the carbon is not burnt, sulphur dioxide and carbon being formed.

Chloroform, bromoform, and iodoform were tried, with the view of making residual vacua, in which water could not exist; but they tarnish the mercury in the pump.

The writer has tried many experiments, with the object of making the exhaustion of lamps quicker and better by adopting other methods altogether. It would make this series of articles too long if many of these were described, but it may be as well to mention a few, as some of them throw some light on the difficult subject of high vacua.

A lamp had a long tube fixed to its nose (Fig. 19). It was then filled with mercury up to the sealing point, and placed in an iron cup full of iron filings and heated. During this part of the experiment a globe was attached to the tube and exhausted, as otherwise the ebullition always bursts the lamp. As the lamp got hotter little bubbles of air collected on the glass, so that the lamp looked as if it was covered with dew, though of course the bubbles were inside. After some time the bubbles began to detach themselves, and when the boiling point of mercury under that pressure was reached brisk ebullition was set up. No bubbles adhered to the glass then, so it appeared that the glass was freed from air. The bulb was then removed, the tube itself was then heated little by little, mercury being added and boiled till the whole was like a boiled barometer tube. Several lamps burst under the pressure of the mercury, and it was very difficult to boil the mercury in the small tube, as it spurted about. When the whole was cool it was inverted under mercury, and the mercury in the lamp ran out, leaving a Torricellian vacuum. A sort of air trap was inserted just above the lamp, the mercury never being allowed to uncover the end when inverted. The lamp was sealed off and the vacuum tested in the usual way. The vacuum was never better than those produced by the pumps. This is strange, but the chief difficulty was in boiling the mercury in the small

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tube. The lamp full of mercury with a long tube attached is very difficult to handle, as the weight is considerable. This experiment was tried several times, sometimes with an empty bulb, so that the vacuum could not be spoiled by gas from the carbon.

Lamps were made which themselves formed the bulbs of little Geissler pumps. After exhaustion they were sealed off top and bottom and tested. This experiment was suggested on noticing the following phenomenon:—If the spark from an induction coil is passed from the lamps to the mercury of the pumps, so as to traverse the phosphoric tube, and the tube from it to the bulb of the pumps, a violet or bluish light is seen. As the vacuum becomes better, this turns green, and finally the only light visible is a few bright green patches on the glass. But before the whole of the tubing shows this—in fact, while it shows a bluish tinge—that part of the tube which was filled with mercury when the elevating pressure was on shows the bright green light. This looks as if mercury has the power of sweeping off the adherent film volume of air. It was easy to see the exact height the mercury had risen to by the sharp division between the bluish and the bright spotty green.

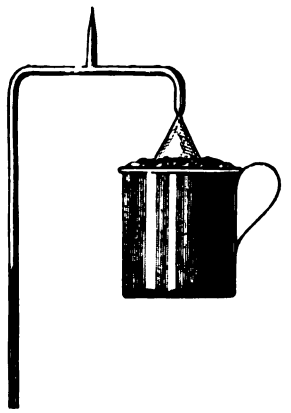

Fig. 20.

A lamp was arranged in the iron filing bath, and filled with mercury (Fig. 20). A bent tube was then sealed on, connected with a vertical Sprengel shaft. A small tube was sealed to exhaust as far as possible, thus bringing the mercury up the Sprengel tube about 30in. The mercury was then distilled out of the lamps. It condensed and ran down the Sprengel tube, so that any air that came off was taken down at the beginning of the experiments. Such experiments as these are very tedious, more especially as so many are spoiled by the lamps or tubes cracking, as it is difficult to work with such fragile apparatus and such a weight of mercury at such high temperatures.

CORRESPONDENCE.

TELEPHONIC INVESTIGATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Mr. Cherrill's article in *The Electrician* of the 24th June must have caused a curious sensation to many of your readers. The writer appears to have arrived at his difficulties in accepting the generally received theory of telephonic action by forgetting or overlooking some of the fundamental principles of acoustics. He says that "On this assumption we must admit that pressure must be in some instances *both increased* and *diminished* at the *same time*." Why? I can see no reason. Sound consists of a succession of "waves" or vibrations, such waves being actually successive differences in air pressure, when air is the medium. Any sound, however complex, can be represented by a curve corresponding to these pressure variations. As it is not possible to conceive of air being at the same time and place both diminished and increased in pressure, it follows that there is no reason to suppose that a telephone diaphragm on the pressure theory ought to be in two places at once. In the case of a complex sound, such as a note and its octave, the impression produced on our ears is due simply to the resultant. The effect on the telephone diaphragm is also simply the resultant. How can it be otherwise? The diaphragm at the receiving end executes similar movements and produces a similar sound. If Mr. Cherrill will be good enough to draw out the waves due to a note and its octave, and get the resultant wave, he will be able to see that his difficulty does not exist.

I have not Tyndall by me, and forget what he says about resultant tones, but I fancy he is using the words in a little different sense to Mr. Cherrill. In the particular case mentioned, since the upper octave of a note has twice as many vibrations as the primary, the resultant, *i.e.*, the difference, is equal to the number of vibrations of the lower note.

It would trespass too much on your space to follow Mr. Cherrill throughout his article, and I will therefore only ask him to explain the action of a phonograph on any other theory than the pressure theory. I put this case because the phonographic action is a purely mechanical one. If to render complex sounds the diaphragm has to be in two places at once, how can the needle point on the diaphragm make a series of impressions on the tinfoil capable of making the diaphragm move in such a way as to reproduce the original sounds and tone? In short, on what theory but the pressure theory can the phonograph be explained? And if the phonograph works from pressure effects, and it is admitted that the resistance of microphonic contacts varies with pressure, why seek further for an explanation? The pressure theory, as applied to the contacts, may be only a rough and inexact one; but so far as the diaphragm is concerned its truth is not open to doubt. I await Mr. Cherrill's own theory with some curiosity.—Yours, &c., Henry M. Sayers.

Lavender-hill, S.W., June 27, 1887.

THE FORBES NONPOLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As far as I understand Prof. Forbes' nonpolar dynamo, it consists essentially of a stationary exciting coil, wound in a circle, within a recess, in a circular armouring of iron, which forms the field portion of the magnetic circuit, and is stationary. The solid iron armature revolves in (and completes the magnetic circuit across) a gap inside the coils, so that as it revolves it must either drive the lines of force round with it, or it must be cut by them as it revolves.

My present difficulty is this—What prevents the lines from going round with the dynamo? I can understand that all will be well if the rings of magnetic force encircling the exciting coil are held *quasi*-fixed by the current in the coil; but if that were so it would answer as well to rotate this coil instead of the armature. But if this is not so, and the form of the field is such that Foucault or other currents cannot be excited in it, then there could be no resistance to prevent the armature carrying the lines round with it. But if, as I take it, the lines are only retarded in their revolution by the resistance to their passage through the field iron ring due to the generation therein of Foucault currents of large quantity, then the lines will only be carried round slowly by their reaction against the revolving armature. Would you kindly inform me if this view is correct? If it is, the stationary iron is as much armature in one sense as the revolving iron, and if the proper form be given to the machine, current might be collected from both the moving and the fixed portions of the iron circuit.—Yours, &c.,

R. Snowdon.

Staveley Ironworks, Chesterfield, June 28, 1887.

[It will probably be interesting if some of our readers will kindly explain their version of the accepted theory of dynamos as applied to the machine in question.—Ed. *E.*]

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: There is much truth in Mr. Mountain's remarks in your current number; but there is also a good deal to be said against his views.

When the owner or the manager of certain works or a

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certain house has made up his mind to adopt the electric light, he has two courses open to him.

He may look round and see other installations, make inquiries as to the contractors who fixed them, choose a good firm whom from all accounts he can safely trust, and place himself in their hands, guarding himself by the simple plan of exacting a guarantee that everything shall go right for a certain time.

Or he may adopt Mr. Mountain's plan of calling in a consulting electrical engineer and placing himself in his hands. Now, it is obvious that very much must depend upon the amount of money which is to be spent. No doubt it would be very much better for all of us if we were to take professional advice before buying anything, even such commonplace articles as beef or mutton, tea or coffee; but we do not, and for two reasons—we cannot afford to do so, and we often do not know where to find anyone who can advise us efficiently on the matter; in fact, in practice we do our best to find out a good, honest tradesman conveniently near our abode, and place ourselves in his hands. If he sells anything we do not approve of we expect him to change it; and if he offends seriously we cease to buy from him. Supposing our tradesman, as frequently happens, to be a man who has been in business a long time, who has perhaps inherited it from his father, he will take good care not to sell us bad materials, or if by accident he does so, will put the matter right immediately he knows of it. I maintain, Sir, that this simple self-acting arrangement is quite sufficient protection for the ordinary transactions in electric lighting work, provided that the firm of contractors chosen are of sufficient standing and have a reputation to maintain. A firm of good standing would rather lose money than have a slur cast upon their work; and this is a far more efficient protection than could be provided by the employment of any consulting engineer, however eminent.

And the same difficulty exists here as in our domestic transactions. Who shall a buyer get to advise him? If he employs the eminent men who stand at the head of the profession, his consulting bill will add very much to the cost of his installation, unless it be a very large one; and, in addition, the actual cost of his installation will probably be higher than it otherwise would have been from the fact that it *may* happen that the eminent man whom he consults has not had much practical experience in the special class of work upon which he is called upon to advise, and therefore almost necessarily specifies more expensive materials than are really required, or than a practical man, with an intimate acquaintance with that class of work, would use successfully.

And if he does not employ the eminent men who have won their name, how can he know that the man he employs knows the work he is called upon to advise on, or that he will not be making experience at his expense? And if any mistakes are made, in place of the contractor paying for them, as he would do under the first arrangement, it is the employer, the user, who will have to pay.

But there is a third plan which is often adopted. Owners and managers in some cases wish to have all the advantages of both systems without the expense. They wish to have the advantage of the competition between rival contractors; but they do not wish to pay an expert to advise them, and to see that the work is properly carried out. They ask everyone whose name they have heard to tender. Usually, if the contract is of any value, the tender is followed up by a call from the representatives of the firms who have tendered, and then the fun begins.

Messrs. A. B. and Co.'s man devotes nearly the whole of the time at his disposal to depreciating the work of everyone else that is in for the job, and if he should succeed in getting a hint that C. D. and Co.'s tender is looked upon rather favourably, he forthwith explains that C. D. and Co. are very nice people, very nice; but if there is one thing they do not understand it is electrical engineering, and if there is any particular branch of which they are hopelessly ignorant, it is the particular work for which tenders have been asked. Then he promises something over and above his tender, in the hope of securing the contract.

C. D. and Co.'s representative goes through exactly the same process, till in the end it is doubtful whether a firm will lose most by taking or leaving the contract, and it is almost a toss up whether the buyer has made a good bargain or a bad one. If the firm he has finally selected, after the wire-drawing process above described, is one of those who have a reputation to lose, and means to support it, he is all right; but if he has chosen, say, a company that winds up a few weeks or a few months after, what security has he that he has got what he wanted or what he intended to buy?

With regard to public tenders the experience of my firm has been rather unfortunate. I will give two instances. We tendered for a contract for which a very eminent engineer had drawn the specification, and which was such as might be expected from a man of his knowledge and experience. We did not get the contract, it went to a firm that no one had ever heard of before, and it was whispered that the reason why the contract went there was because that firm would use a particular form of apparatus in which the engineer was interested. Whether this be true or not—I merely give the whisper for what it is worth—no one will deny that such a thing would be possible in certain cases. Consulting engineers are but human, and would naturally view with favour apparatus in which they have had a finger.

In the other case we were second, our tender being rather less than the bulk of the other tenders, and the one that was successful being considerably below any of us. The company that secured the contract did not live to complete it; but no fresh tenders were asked for, nor, though by the rules under which the failing company's tender had been accepted it should then have fallen to us, were we even communicated with. Under the circumstances of these and other tenders we considered we should do wisely in saving the money we should be obliged to spend in these competitions for the purpose of developing sound business. I think the above will show that the matter is by no means so cut and dried as Mr. Mountain's experience has led him to imagine.—Yours, &c.,

SYDNEY F. WALKER.

PROGRESS OF ELECTRIC LIGHT IN SWITZERLAND.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A few days ago, at Engelberg, a valley under the Titlis mountain in Switzerland, I was present at the preliminary trial of an electric light installation, a brief notice of which may be of interest to your readers. There are now in Switzerland a considerable number of installations, in which the ample supplies of water coming from the heights are used as the motive power. The Engelberg installation is the newest of these, and is highly satisfactory.

The village of Engelberg is a straggling little place about a quarter of a mile in length, in the midst of a fertile valley, and surrounded with mountains and high hills. There are several hotels; and nearly at the two extremities of the village are two—the Engel and the Hotel Titlis—owned by the same proprietor, Herr E. Cattani. The larger of these, the Titlis, a very handsome and well-appointed hotel, is supplied with electric light throughout, and the gardens and front of the house are lighted with arc lights. An arc light is also placed opposite the entrance of the smaller Engel, though the lighting is not yet carried through the interior.

The engine house is at a distance of 160 metres from the Hotel Titlis, and the water is brought to the turbine from the hills above by means of 270 metres of wide iron pipe. The quantity of water supposed to be available at all times is 200 litres per second; and the available fall is 25 metres, which gives nearly 70 *force de cheval* (over 60 horse-power). The turbine used is a turbine Girard (horizontal shaft), capable of yielding from 45 to 50 *force de cheval*; and the arrangements for regulating the supply of water, &c., are admirably convenient, though I cannot attempt to describe them without drawings. The shaft of the turbine is clutched on to a long horizontal shaft, from which the present dynamo is driven; and it is proposed, should the water-power be found at all seasons to fulfil present expectations, to drive a second large dynamo,

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which will light up the Hotel Engel, and supply also a neighbouring Pension.

The dynamo is a powerful and beautifully finished Schuckert machine, calculated, I believe, for 500 lights. At present 300 Siemens 101 and 102-volt incandescent lamps are being used in the hotel. There are also five arc lamps, about 1,000 candles each, placed in the grounds, and one near the entrance of the Engel.

The mains are very heavy copper wires, which are supported, between the engine house and hotels, on poles like telegraph poles, and throughout the interior of the Titlis the electric light arrangements are made with great simplicity and with excellent taste.

The installation is the work of Stirnemann and Weissenbach, of Zurich.—Yours, &c., J. T. BOTTOMLEY.

Grindelwald, Switzerland, June 18, 1887.

THE INTERMINABLE TERMINOLOGIST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Seduced by your paragraph on the subject of electromagnetic terminology last week, I turned to the article to which you so flatteringly referred in the hope of finding something that might be useful to a practical man; and I do not deny that in that article, as well as in the singular letter which follows it to-day, some valuable hints and promising terms are my reward, though they would have inspired greater confidence had they not been disfigured by personalities which are in very bad taste, and eccentricities of diction which are beneath the subject under treatment. Mr. Heaviside is a great scientist; he implicitly declares it when belittleing somebody whom apparently he cannot abide; and, indeed, you will remember he has virtually "sworn it." Probably nobody will contradict him; I certainly will not; but it naturally occurs to smaller men than he that as high science itself is at loggerheads about its own terminology, and that as even this ingenious coiner of phrases has not yet so much as satisfied himself, it behoves him to be merciful to those whom high science may have misled or failed to enlighten. Mr. Heaviside, in to day's letter—and not for the first time—contemptuously refers to those who have unfortunately misunderstood Clerk Maxwell. Yet Mr. Heaviside himself later on asserts (as I think somewhat impertinently) that "it was very much his own fault" if Maxwell is "still to be fully appreciated"—which appears to be Heavisidean English for "not yet quite understood." Well, if Maxwell's expositions are anything approaching Heaviside's in obscurity, no wonder. The very sentence, consisting only of three lines, in which the unfortunate person is trounced who "could not see the force of Maxwell's argument," &c., can be construed in at least three different and opposite ways, through the slipshod use of the word "because." Am I hypercritical? Well, then, cast your eyes further down Mr. Heaviside's remarkable letter. "Conductances are the proper things to use." What sort of *things* are conductances, and how do you *use* them? Again, "with condensers, on the other hand, permittances are most useful." Would condensers be any less useful without permittances, and why are permittances most useful with condensers on the other hand? Next, we are told that "should, however, we join in sequence, then elastances are the proper things." It is satisfactory to learn that elastances are "proper," even under the conditional "should, however, we join in sequence;" but one would like to be sure where the impropriety comes in supposing we do not join in sequence, and would the Lord Chamberlain interfere? In his concluding paragraph Mr. Heaviside lets fall one of those dark and oracular sayings with which his writings so painfully abound, "The most absolute of all ways of finding the inductance of a coil is with a tape." It would appear from this that there are several ways of finding inductance, some of which are absolute ways, while others are more absolute; but that the most absolute is "with a tape." Very well; but we want to know what is to be done with it when we have found the creature? Many of Mr. Heaviside's readers say "Hang it;" but in that case its resistivity would be more effectually overcome (probably without its permittance), and its attenuation more certainly insured, by employing a piece of string. But this is a distortion. To return to the point, Mr. Heaviside tells us that the term "mac" is quite euphonious and unobjectionable. If that be granted, so, too, is smack; and for any scientist who takes unwarrantable liberties with his readers, or who drags his personal feelings into public print, or makes *un-*"meaningful" perversions of the English language, smack is really the only absolutely proper thing to use.—Yours, &c.,

24th June, 1887. AMICUS.

[We think, of course, that this letter is really too bad; but our readers will agree with us that in another sense it is rather too good to be lost.—ED. *E.*]

SUMMER COURSES OF LECTURES AT THE CITY AND GUILDS OF LONDON INSTITUTION.

A course of evening lectures (from 8 to 9 p.m.) on "Methods of Determining the Fundamental Standards of Electrical Measurements," will be delivered by Mr. R. T. Glazebrook, F.R.S., at the Central Institution, Exhibition-road, on Monday, Tuesday, Thursday, and Friday next. On the afternoons of Tuesday and Friday there will also be practical demonstrations in the laboratories. The following is a syllabus of the course by Mr. Glazebrook:—

I.—*Preliminary.*—Definitions and explanation of terms ohm, ampere, volt, farad. Theoretical considerations connected with some fundamental measurements; the ballistic galvanometer. Measurement and comparison of coefficients of self and mutual induction.

II.—*The Ohm.*—Absolute measurement of resistance. General principles of various methods:—1. Method of the B. A. Committee. 2. Weber's method. 3. Kirchhoff's method. 4. Lorentz's method. 5. Other methods. Summary of results.

III.—*The Ampere and Volt Measurement of Current and Electromotive Force.*—Principles of various methods:—1. The Electrodynamometer. 2. Current weighing. 3. Kohlrausch's method. Standards of current and electromotive force; the silver voltameter; Clark's standard cell.

IV.—*The Farad.*—Measurement of capacity. 1. The ballistic galvanometer method. 2. Method with a tuning fork. Construction and comparison of standards.

The course of lectures on "Testing Dynamos and Motors," delivered by Prof. Ayrton in the spring, will be repeated during the fortnight from July 5th, and with the practical demonstrations will occupy from 10 a.m. to 4 p.m. daily.

FRIEDLAENDER'S PORTABLE LAMP.

A portable incandescent lamp and primary battery, devised by Herr Friedlaender, of Berlin, is illustrated in the accompanying figures. The box is made of ebony, measuring 7in. × 4in. × 4in.,

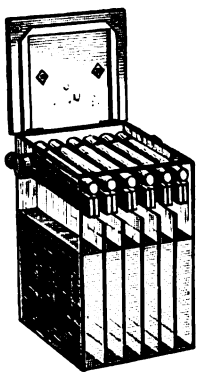

FIG. 2.

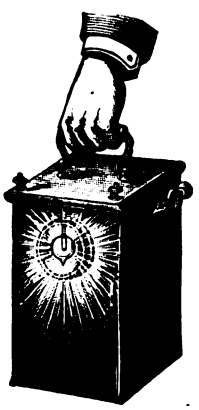

FIG. 1.

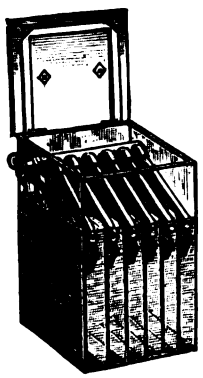

FIG. 3.

and is divided internally into six compartments, each of which contain a pair of zinc and carbon electrodes. The solution consists of a mixture of chloride of zinc and potassium bichromate, and has the advantage of entire freedom from either fumes or smell. With a lamp of 3 candle-power the solution is said to cost about 2d. per lamp hour. The plates are withdrawn from the cell by turning a knob at the side of the box, which lifts the electrodes out of the solution. Fig. 1 shows the external appearance of the cells, and Figs. 2 and 3 show the internal arrangements.

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TO CORRESPONDENTS.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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A HALF CENTURY OF TELEGRAPHY.

A few years back, when the craze for centennial celebrations was at its height, the suspicion arose that every great man must have flourished and every remarkable event must have occurred exactly one or more centuries ago. The promoters of these anniversaries experienced no difficulties in regard to dates. If the great man was not born in the particular year required he obligingly died in that year, or he did something that constituted an epoch or a landmark at the quite correct moment. Anyway, the centenary was celebrated with becoming enthusiasm, if not always with rigid respect to dates. In the case of the Jubilee which has just been—or, rather, is still being—celebrated throughout the length and breadth of the land no such historic doubts have crept in; and similarly with regard to the proposed Jubilee commemoration of the telegraph, foreshadowed in our last issue, the year and the day are as nearly coincident as the exigencies of public life will permit. The first electric telegraph of a really practical sort in this country was worked on the evening of July 25, 1837, and on Wednesday evening, July 27, 1887, its fiftieth birthday is to be appropriately celebrated. It was in the precincts of the metropolis—that is to say, between the Euston-square and Camden Town Stations—that the first electric telegram was flashed, and within a mile or two of that famous spot the living representatives of WHEATSTONE and COOKE will do honour to their memory, and proclaim with characteristic festivity the national pride in these fifty years' fruit of their labours.

In another column will be found the particulars of the proposed gathering, which it is understood will take the form of a banquet, where every Englishman of mark whose name is associated with the rise and progress of telegraphic enterprise we feel sure will be present. It will, we imagine, be an essentially English celebration; we do not mean exclusively so; that may be as it happens. But the occasion being one to mark the origin and rise of an English invention, the expansion of which has been largely, and in one branch of it wholly, due to British science, British capital, and British energy, the assembly ought to be British, and the demonstration a national one. Our claim to have invented the electric telegraph may be disputed both on the Continent of Europe and in America, but nobody has questioned the originality and utility of the system we propose to commemorate as our own, or denied the rapidity and vigour with which we have turned it to account in every corner of the world. It was in "a dingy little room, and by the light of a flaring dip candle" that the first words of the electric messenger over a distance of less than two miles were spelled out. Only fifty years have elapsed since that memorable night; and we see the whole world entwined in a network of myriads of miles of wire; and from the shabby little office in Euston square, the mind naturally turns to the gigantic proportions and splendid equipments of the English Central Telegraph Station to day. From the Holborn Restaurant, where the banquet is to be held, and where the electric light—itself an outcome of electrical research—will illuminate the proceedings, every word that is spoken might be transmitted to the other side of the Atlantic in less time than it took those two famous amateurs to make their first essay in telegraphy. That "tumultuous sensation" which WHEATSTONE experienced on hearing the click of the needles may in some degree be shared by us to-day; and if it be true that he felt "all the magnitude of the invention then proved to be practicable beyond cavil or dispute," the realisation of his wildest dreams has added fresh lustre to his name by attesting his boldness and foresight.

We have said that the claims of England for priority in the invention of the Telegraph may be disputed, and we have no need to assert them here. Prof. MORSE, who was working on a different line to attain the same end as that of WHEATSTONE and COOKE in this country, has claimed and received the distinction in his own person for America. But it is on record that MORSE publicly complained of "WHEATSTONE in England and STEINHEIL in Bavaria, who have their electric telegraphs, being afforded the means of bringing forward their methods, while to my invention of earlier date than theirs my country seems to show no favour." These words are at all events conclusive as regards the respective countries, whatever they may be as touching the individuals, whose relative merits are really never in question. What we as a country may fairly claim is that the first acceptance and application of electric telegraphy to practical uses was by England just fifty years ago. Perhaps, too, we have a further distinction in the GROVE and the DANIELL batteries, the latter of which contributed immensely to the success and development of the system, and, it is worth remembering at this time, dates from the same period—probably the same year—as the COOKE and WHEATSTONE telegraph; and both DANIELL and GROVE were Englishmen. We have therefore every reason to join in this Telegraph Jubilee without misgivings as to our title to do so, and although the celebration, like many others, owes its suggestion to the jubilant temper which pervades the breasts of

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all true Britons just now, the telegraph has done so much for the social well-being, the material prosperity, and the stability of our empire, that this particular fiftieth anniversary could not with decency have been passed over in silence.

LITERATURE.

A Century of Electricity, by T. C. MENDENHALL. (London: Macmillan and Co.)

This is one of the Nature Series, of which some seventeen volumes have already appeared, treating scientific subjects in a popular manner, and most of them by Englishmen of scientific repute. Why the volume under review should have been chosen as the sole representative of electrical science is more than we can understand. It is American both in tone and treatment; and it fulfils none of the conditions required by English readers either from a scientific or a popular point of view. Yet it is here put upon the English market by an English firm expressly for English readers; whereas internal evidence conclusively proves that the author is conscious of none but an American audience. The fact of its reproduction by publishers so respectable as Macmillan and Co. would seem to imply that there is a great demand for electrical information in this country and nobody here competent to supply it. Or it may be that the book in question, or its author, has obtained such a great reputation in America as to warrant an English edition in preference to anything that could be had here. And this may very well be the case, for the book possesses considerable merit, both literary and constructive, of exactly that kind which finds favour in America, where broad notions of things in general are sought after rather than thorough and exact knowledge of any one subject in particular. But "A Century of Electricity" has no conceivable place in English scientific literature, and it fills no gap which could not have been as easily supplied by any hack writer provided with a biographical dictionary and a few elementary Electrical Text Books. As an historical sketch it may count for something, although its limitation to the century is quite arbitrary, and chiefly confined to the title page; whilst those portions which are devoted to description—in which the author really excels—are rendered valueless and illusory by the necessary restrictions of a small volume. Two hundred pages are far too few for any adequate treatment of the subjects he has taken in hand. And in this attempt he has not been assisted by the publishers, the illustrations being extremely meagre, and most of them as bad as they well could be. We have said that the book has some literary merits; and where the author sticks to his plain task he is really quite admirable. Not unfrequently, however, and more conspicuously in his opening and concluding chapters, he yields himself to the oratorical flights which are characteristic of the American platform, but in essaying which Mr. Mendenhall utterly and ludicrously fails. In short—and this is why we have noticed it at all—if that kind of book were wanted on this side of the Atlantic it could be done very much better by an English writer. Such as it is its attractive title may help to sell it; but unless we are greatly mistaken every reader who has bought it will consider himself sold.

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XLII.

BY OLIVER HEAVISIDE.

Speed of the Current. Effect of resistance at the sending end of the line. Oscillatory establishment of the Steady State when both ends are short-circuited.

Although the speed of the current is not quite so fast as the square of the length of the line, yet, on the other hand, it is not quite so slow as the inverse square of the length, as a writer in a contemporary (*Electrical Review*, June 17, 1887, p. 569) assures us has been proved by recent researches. However, if we strike a sort of mean, not an arithmetric mean, nor yet a harmonic mean, but what we may call a scienticulistic mean (whatever *that* may mean), and make the speed of the current altogether independent of the length of the line, we shall probably come as near to the truth as the present state of electromagnetic science will allow us to go. But, apart from this, there is some *a priori* evidence to be submitted. Is it possible to conceive that the current, when it first sets out to go, say, to Edinburgh, *knows* where it is going, how long a journey it has to make, and where it has to stop, so that it can adjust its speed (scienticulistic speed) accordingly? Of course not; it is infinitely more probable that the current has no choice at all in the matter, that it goes just as fast as the laws of Nature, preordained from time immemorial, will let it; and if the circuit be so constructed that the conditions prevailing are constant, there is every reason to expect that the speed will be constant, whether the line be long or short. Q.E.D.

Now, a great and striking thing about the non-distortional system, whose elementary properties were discussed in the last section, is the distinct manner in which it brings the speed of the current into full view. Another and very important thing is this. When the leakage is not so adjusted as to remove the distortion altogether, solutions become difficult of interpretation, owing to the almost necessary employment of Fourier or other transcendental series to express results. But by a proper adjustment of the leakage so as to abolish the tailing, which is the cause of the mathematical difficulties, we are enabled to follow with ease the whole course of events, say, in the setting up of the final state, due to a steady impressed force, without laborious calculations. And, although the state of things supposed to exist in the non-distortional system is rather an ideal one, yet it allows us to obtain a very fair idea of what happens when there is distortion, *e.g.*, in the oscillatory establishment of the steady state in a well-insulated circuit.

When we speak of a charge travelling along a wire at speed v, it should be always remembered what this implies. There are two conductors, parallel to one another, and the positive charge on the one is accompanied by its complementary negative charge on the other (corrections due to parallel wires, &c., are ignored here). The two charges move together. More comprehensively, the whole electromagnetic field, of which the charges are a feature only, is moving along at speed v in the space between the wires, into which it also penetrates to a greater or less extent. In the non-distortional system this penetration is assumed to be perfect and instantaneous, so that the resistance and the inductance are strictly constants; and by the ratio R/L being made equal to K/S we make any isolated disturbance travel on without spreading out behind. In travelling it attenuates by loss of energy in the conductors and by leakage in such a way that if it attenuate from 1,000 to 900 in the first 50 kilometres, it will attenuate to 810 in the second, to 729 in the third, and so on; multiplying by 9/10 in every 50 kilometres.

In the last section was considered the uniquely simple case of a short-circuit at A, the beginning of the circuit, where any impressed force is placed, sending any shaped waves into the circuit, travelling undistorted, with uniform attenuation, and completely absorbed on arrival at the distant end B by a terminal resistance of amount Lv. Of course this complete absorption at B of all waves arriving there is independent of the nature of the terminal arrangements at A. But these will materially influence the magnitude of the waves leaving A. Keeping at present entirely to simple cases, if we insert a resistance Lv at A we can make a safe guess that the current will be just halved, because when there is a short-circuit there the line itself behaves just as if it were a resistance Lv. That is, the current at A is then e/Lv, however e may vary, provided there be a resistance Lv at B; or, which is equivalent, the circuit be continued indefinitely beyond B unchanged in its properties. This guess may be easily justified. That the current is zero when we insulate, or insert an infinite resistance at A, is also evident. In general, the insertion of a resistance R_0 at A causes the potential difference V_0 there due to an impressed force e to be

$$V_0 = eLv(R_0 + Lv)^{-1} \quad . \quad . \quad . \quad . \quad (15a)$$

and the current to match to be V_0/Lv. The transmission to the distant end, and the attenuation are as before.

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But if the place of e be shifted along the circuit from A, interferences will result whenever the resistance at A has not the value Lv. Imagine e to be at distance x_1 from A. When put on, the result is to send a positive wave $\frac{1}{2}e$ to the right, and a negative wave $-\frac{1}{2}e$ to the left, both travelling at speed v, and attenuating similarly. Thus the circuit behaves towards e as a resistance $2Lv$, half to the right, half to the left. Now, when the negative wave arrives at A, if there be a resistance Lv there to absorb it, there will be no interference with the positive wave, which will go on to B and be absorbed there. The current at B will therefore be

$$C_B = \tfrac{1}{2}(e/Lv)\epsilon^{-R(t-x_1/v)} \quad . \quad . \quad . \quad (16d)$$

the value of e to be taken at a given moment being that at x_1 at the time $(t - x_1)/v$ earlier. But if there be a resistance at A of any other amount than Lv, there will be a reflected wave from A, which will run after the original positive wave, and so make every signal at B have a double or familiar following it after an interval of time $2x_1/v$, which is that required to go from x_1 to A, and back again. Now the closer the seat of e is shifted towards A, the more closely will the familiar follow the original positive wave; and when e is at A itself, they will be coincident in front. Now, the current at A corresponding to (16d) is

$$C_A = \tfrac{1}{2}(e/Lv)\epsilon^{-Rx_1/Lv}; \quad . \quad . \quad . \quad (17d)$$

and (as will be explained in the section on Reflections) the reflected wave is got by multiplying by ρ_0, where

$$\rho_0 = (R_0 - Lv)(R_0 + Lv)^{-1} \quad . \quad . \quad . \quad (18d)$$

Now make $x_1 = 0$ and we shall verify (15d), and, by the union of the positive and reflected also positive wave, show that V at x at time t due to $e = f(t)$, any function of t, at A is

$$V = f(t - x/v) \times Lv(R_0 + Lv)^{-1} \times \epsilon^{-Rx/Lv}, \quad . \quad (19d)$$

and the current there is V/Lv.

The most simple case after these of complete absorption at B, with complete absorption, or short-circuit, or any resistance at A, is perhaps that in which we short-circuit at both A and B. If a charge be then moving towards B it is wholly reflected with reversal of electrification. We must have $V = 0$ at B, and this requires every disturbance arising at B to be at once reversed and sent back again. The same thing happens at the short-circuit at A. Perhaps, however, the easiest way to follow events is to imagine the two charges, positive and negative, which always travel together, to pass through one another when they come to the short-circuit, so as to exchange wires. Thus one charge goes round and round the circuit one way, whilst the other, just opposite, goes round and round the other way. There is the usual attenuation. On this view of the matter, we may imagine the effect of a terminal resistance Lv to be simply to bring the charges to rest against friction. It need scarcely be said, however, that the day has gone by for any such fanciful explanation to be taken seriously.

Since the current in a negative wave (from B to A) is of the opposite sign to the electrification, there is no reversal of current by reflection at a short-circuit. As, therefore, the reflected wave is to be superimposed upon the incident wave, we see that the current is doubled at B from what it would be were the circuit to be continued beyond B, or the critical resistance Lv were inserted in place of the continuation.

The process of setting up the permanent state due to a steady e at A is now this. First the positive wave

$$V_1 = e.\epsilon^{-Rx/Lv}. \quad . \quad . \quad . \quad . \quad . \quad (20d)$$

if $x < vt$, which would be the complete solution were there no reflection at B. Now B is reached by V_1 in the time l/v, and the value of V_1 at B just on arrival is $e\rho$, if $\rho = \epsilon^{-Rl/Lv}$, which is the attenuation in the circuit. The reflected wave V_2 now begins. This is

$$V_2 = -e\rho^2.\epsilon^{Rx/Lv} \quad . \quad . \quad . \quad . \quad (21d)$$

which travels towards A at speed v. In the meantime the first wave V_1 is still going on, for the battery at A does not know what is going on at B. Thus, from $t = l/v$ to $t = 2l/v$ the state of the circuit is given by the sum of V_1 and V_2 so far as V_2 has reached, and by V_1 alone in the rest. On arrival of V_2 at A it is attenuated to $-e\rho^2$, and reflection then produces a positive wave

$$V_3 = e\rho^2\epsilon^{-Rx/Lv}, \quad . \quad . \quad . \quad . \quad . \quad (22d)$$

which is a copy of V_1, only smaller to the extent produced by the multiplication by ρ^2. This wave reaches B when $t = 3l/v$, and then there commences the reflected wave, V_4, given by

$$V_4 = -e\rho^4.\epsilon^{Rx/Lv}. \quad . \quad . \quad . \quad . \quad (23d)$$

going from B to A. This is a copy of V_2. And so on. Thus we have an infinite series of reflected waves, coming into existence one after the other; the state at any moment is expressed by the sum of the waves already existent; the final state is the sum of them all. Since the sizes of the positive waves form a geometrical series, and also those of the negative waves, they are easily summed. The positive waves V_1, V_3, &c., come to

$$e(1 - \rho^2)^{-1}\epsilon^{-R./Lv}. \quad . \quad . \quad . \quad . \quad (24d)$$

and the negative come to

$$-e\rho^2(1 - \rho^2)^{-1}\epsilon^{Rx/Lv}; \quad . \quad . \quad . \quad . \quad . \quad (25d)$$

so that the sum of (24d) and (25d) expresses the final V of the circuit. And, since the current is got by dividing by Lv in a positive wave and by $-Lv$ in a negative, the final current is the excess of (24d) over (25d) divided by Lv. Notice that whilst it is a process of settling down to the final state of electrification, it is a process of rising up to the final state of current. More strictly, whilst the potential difference at any spot oscillates about its final value, being alternately above and below it, the excursions getting smaller and smaller as time goes on, the current increments are all positive, though they get smaller and smaller. Now if the time l/v of a journey be exceedingly small, so that there may be thousands of journeys performed in getting up to say 99 per cent. of the final current, the current will appear to rise continuously, and the potential difference to have its final value from the first moment, which is in reality its mean value during the oscillatory period. This is the explanation I have before given of how it comes about that there is no sign of oscillation in any purely electromagnetic formulæ, such as are universally employed when such short circuits are in question that the current seems to have the same strength (when no leakage) everywhere. It is really rising by little jumps, and differently timed at different places, but the jumps are too small to be perceived, and too rapidly executed. And the electrification is really (unless the vibrations are specially checked) vibrating about its mean value at any spot, which is its final value, though this mean value is assumed (in electromagnetic formulæ) to be the actual value. But if the resistance in circuit be great, so that the final current is small, we have an oscillatory settling down of the current instead of a rise.

The solution (24d), (25d) is what we may at once get by considering the differential equation of the steady state and its solution to satisfy the terminal conditions. But our solution gives us the whole history of the establishment of this final state, and allows us to readily follow the oscillatory phenomenon into minute detail. When there is distortion there is difference in detail, which is then difficult to follow; but there is no substantial difference in the general results. We cannot make or break a circuit without a similar action in general. But we cannot expect to be able to simply formularise the results when the circuit is of an irregular type, *e.g.*, a laboratory circuit.

(To be continued.)

ADMIRALTY SPECIFICATION FOR ENGINES AND DYNAMOS.

Admiralty contracts for electric lighting *materiel* have hitherto been awarded within a comparatively narrow range of the best known firms, but we are sure that a large number of electrical engineers will be interested in the terms of a recent specification issued by the Director of Navy Contracts for the supply of engines and dynamos for ship lighting. We reproduce the specification verbatim, but in the schedules we have omitted the names of the firms to whose dynamos and

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SCHEDULE. (Blanks to be filled in by the contractor.)

No. of sets required.	Dynamo. Current	E.M.F. at machine terminals.	Length of brush working surface.	Revolutions per minute. With single acting closed engines.	Revolutions per minute. With double acting open engines.	Spare armatures required.	Engine. Guaranteed consumption of water per hour per electrical horse-power of 746 watts.	Working steam pressure per square inch.	Water pressure tests. High pressure cylinder, &c.	Water pressure tests. Low pressure cylinder, &c.
	Amperes.	Volts.	Inches.	No.	No.	No.	lb.	lb.	lb.	lb.
6	400	80	—	400	250	1	—	90	225	135
6	300	80	7	400	250	1	—	90	220	130
1	300	80	7	400	250	—	—	40	120	—
4	200	80	5	450	300	1	—	90	230	140
2	200	80	5	450	300	1	—	75	200	110
3	200	80	5	450	300	1	—	40	120	—
6	200	80	5	450	300	—	—	—	—	—
7	200	80	5	500	300	1	—	15	60	—

DIMENSIONS OF COMBINED DYNAMO AND ENGINE OFFERED.

Combination.	Length of bed-plate and over all.	Width over bed-plate and over all.	Total height of engine and necessary height for removal of working parts.	Weight, including spare gear. Dynamo.	Weight, including spare gear. Engine and Bed-Plate.	Weight, including spare gear. Total.	Time required for delivery and time to reckon from date of receipt of order.
	Ft. Ins.	Ft. Ins.	Ft. Ins. (*To be filled in by firm tendering,*)	Cwt.	Cwt.	Cwt.	

engines the contract was restricted. We see, however, no reason why the list should not be considerably extended :—

Specification

1. The engines are to be direct acting, of approved economical type, to be mounted and coupled to the dynamo, on a strong cast iron bed-plate, sufficiently stiff to fix to a 3in. fir deck without special wood bed, and planed on the under side.

2. The cylinders are to be of hard close grained cast iron, with gun-metal bushes and glands, with efficient sight feed lubricators, and with all necessary drain cocks, &c. Suitable means are to be fitted to enable the indicated horse-power of the engines to be ascertained. The cylinders and adjacent parts are to be cased with approved non-conducting material and mahogany or other approved covering. The driving shaft and connecting rods to be of steel, with bearings of gunmetal or phosphor bronze, or these lined with white metal. All moving parts to have large bearing surfaces, to be well balanced, to admit of ready adjustment, and fitted with efficient means of lubrication. All non-working parts are to have three coats of oil paint before leaving the contractor's premises.

3. The engine must be capable of working the dynamo, with the full load, the steam pressure, and at the speed stated in the schedule, when exhausting into the atmosphere, without knocking, undue vibration, or heating of bearing surfaces. When fitted on board the vessel the engine will be arranged to exhaust into a condenser as well as into the atmosphere, and it must work efficiently under these circumstances.

4. A governor capable of adjustment when running, or on other approved principle, is to be fitted to control the speed of engine. The variation of speed allowed by this governor when all the load is removed is not to exceed 5 per cent.

5. A pulley, 4in. in diameter and 1½in. wide, is to be fitted on the engine shaft in a suitable position for driving a revolution indicator.

6. The cylinders and all other parts subjected to steam pressure are to be tested by water to the pressure stated in the schedule before being painted or lagged, in the presence and to the satisfaction of the inspecting officer. The Admiralty are to be informed when the engines are ready for this test.

7. The dynamos are to be of the direct current type, and self-regulating. Each must be capable of generating and sustaining a steady current of the amperes stated in the schedule, with an E.M.F. of 80 volts at machine terminals when running at the speed stated in the schedule for the types of engines specified. A variation of more than 5 per cent. from the schedule speed will render them liable to rejection.

8. The dynamos are to be self-regulating for constant E.M.F. of 80 volts for all loads from 10 amperes to full load, at the specified speed, and capable of maintaining continuously the full current without sparking at the brushes, undue wear of the collector, or injurious heating of any part of the machine circuit in a temperature of 120 deg. Fahr. No part of the machines to be more than 20 deg. above the temperature of the atmosphere.

9. The armatures are to be well balanced and to run true, the whole to be well secured to the steel shafts, properly supported on long bearing surfaces, and efficiently lubricated.

10. The collector sections are to be of hard copper, insulated with mica ; they are not to be less than 1½in. deep, and not less than 80 in number for ring armatures and 50 in number for drum, and to have a brush working surface not less than that stated in the schedule, the whole to be well secured together, and to the armature coil and shaft.

11. The brushes are to be supported on a rocking bar capable of easy adjustment, three on each arm for machines of 400 amperes, two on one arm and three on the other for machines of 300 amperes, and two on each arm for the other sizes, each brush to be 2in. by ½in. by 7in., and to have a separate holder, spring adjustment with forward thrust, suitable hold-off catches, and to stand at an angle of about 50deg. to the surface of the collector at point of contact.

12. All working parts to be easily accessible for adjustment, examination, and repair.

13. The whole of the circuit of the dynamo to be of copper, with a conductivity of not less than 96 per cent., well insulated, the whole to be properly insulated from every part of the machine frame, and coated externally with varnish insoluble in water or oil, and of such a nature as not to become brittle from the heat of the copper, and the insulation of the machine circuit is to be such that during the official trial no spark can be obtained, by making intermittent contact with a piece of copper wire between the iron frame of the machine and either brush.

14. At Portsmouth Dockyard the engines and dynamos will be subject to a test of six hours continuous run with full load, and exhausting into the atmosphere, during which trial the consumption of water will be ascertained, and the apparatus will be required to satisfy this specification in every respect, without injury to any part of engines or dynamos. The engines must be capable of standing the removal of the whole load, by sudden break of the circuit, without injury.

15. Spare gear for the engines and dynamos is to be supplies for each set, in accordance with what may be considered necessary by the Admiralty, for the particular type of apparatus adopted. A list of such articles is to be submitted by the contractors for approval. The spare gear is to include the following items :—

Brushes complete for each dynamo	2 sets
Piston rings for cylinders, if so fitted	2 sets
Brasses or bushes for working parts	1 set
Springs for governor	1 set
Special spanners	1 set

The spare gear to be tried in place on the contractor's premises, in the presence and to the satisfaction of the inspecting officer.

16. Spare armatures for ships having two or more machines must be suitable for either machine.

17. The economy of working of the engines is of great importance. The contractors are to insert in the schedule consumption of water per hour per electrical horse-power of 746 watts at machine terminals they are prepared to guarantee on the official six hours' trial at Portsmouth. Should the actual consumption per hour, on this trial, as reported by the dockyard officers, exceed that guaranteed, a deduction from contract price will be made for each excess of 1lb. per electrical horse-power per hour, according to the following scale :—

400 ampere machines	£16
300	12
200	8
100	4

Should the consumption of water per electrical horse-power per hour exceed that guaranteed by 10lb., the engine and dynamo may, at the option of the Admiralty, be totally rejected.

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18. Special care is to be taken in designing the apparatus, so that the weight and space required for it, and for removal and access to all parts, is reduced to a minimum.

19. The contractors will be held responsible for the efficiency of the whole of the apparatus supplied till the expiration of a period of 12 months from the date of receipt, and any parts which during that period may be found defective or showing symptoms of weakness, owing to faulty design, materials, or workmanship, must be removed, and others substituted for them, by the contractors at their own expense, or the defects may, at the option of the Admiralty, be made good at the dockyard, and the cost charged against the contractors. The cost of making good any defects which may arise from fair wear and tear, or from improper management by the staff of the ship, will be borne by the Admiralty.

20. A tracing on cloth, showing clearly, in full detail, the arrangement of the engine and dynamo, and a copy of instructions for the care and management of the apparatus, are to be supplied with each machine, if required, also one copy of each for the Admiralty Office.

PARTICULARS OF ENGINES AND DYNAMOS (to be filled in by the contractor).

Engines—	
Number of cylinders	—
Diameter	—
Length of Stroke	—
Diameter of steam pipe branch supplying the cylinders	—
Diameter of exhaust pipe branch from the cylinders	—
Spare Gear—	
Piston rings for cylinders (if so fitted)	—
Brasses or bushes for working parts	—
Springs for governor	—
Special spanners	—
Dynamos—	
Description of dynamo	—
Brushes	—

The following is a list of the ships for which the machines were required:—"Victoria," "Sans Pareil," "Australia," "Galatea." "Narcissus," "Ajax," "Serpent," "Racoon," "Thames," "Northampton," "Curaçoa," "Iris," "Emerald," "Boadicea," "Canada," "Carysfort," "Superb," "Swiftsure," and "Volage."

THE JUBILEE OF THE TELEGRAPH.

A numerously attended meeting of the gentlemen who have been appointed a general committee to make arrangements for celebrating the fiftieth anniversary of the construction of the first practical electric telegraph in England was held on Tuesday, at the offices of the Society of Telegraph-Engineers, 4, The Sanctuary, Westminster.

On the motion of Prof. HUGHES, F.R.S., Mr. W. H. Preece, F.R.S., of the Telegraph Department of the Post Office, was voted to the chair.

Mr. WEBB (the secretary) having read the notice convening the meeting,

The CHAIRMAN said that the first practical test of the telegraph was made in England on July 25th, 1837, by Messrs. Cooke and Wheatstone on the railway between Euston and Camden, and it was owing to the success that attended that experiment that they succeeded in getting the assistance of Stephenson, George Parker, Brunel, and of other well known men of that day to help them in the development of the idea. From that small beginning they had seen how the telegraph had spread like a network all over the face of the world, and how in England, where the first step was taken in its practical application, they had succeeded up to the present in keeping well in the van of the progressive development of the science. It therefore seemed a fitting thing that such an important event among the many other notable achievements that had been made during the long reign of Her Majesty, which had just been celebrated, should be in some way commemorated, and that those who had been instrumental in bringing telegraphy to its present position of importance in the world should meet together, and take the opportunity of collecting around them many who were still living, although they were not now seen amongst them, but whose names were well known in connection with telegraphy in the earlier years of its history, for the purpose of publicly celebrating the occasion. It happened that the proper day on which they ought to celebrate what he would call their Jubilee was July 25th, but there were several good reasons why it was extremely difficult to fix upon that date. In the first place, Monday was a day on which their legislators were very busy in the House over the way, and it would be very difficult for the committee to get any members of Parliament to attend on that day. Again, it was quite impossible on a Government night like Monday to get the Postmaster-General to take the chair, and as that gentleman was at the present time the representative of the principal telegraph interest of England, it was thought proper that he should be invited to preside on the occasion. On July 23rd, on the other hand, there was going to be a great Naval Review at Spithead, and as a good many of their friends who would like to be there would not get back until Monday afternoon, it was thought that Wednesday, July 27th, would meet the wishes and convenience of everybody. After consultation with Mr. Alabaster and Mr. Biggs, and a few others, they agreed not to raise the question of the best day but to fix upon the 27th July. The first thing that they had to do, therefore, was to decide that it was desirable that a dinner should be held on the 27th of July, to celebrate the Jubilee of the electric telegraphs. He concluded by formally moving a resolution to that effect, which having been seconded by Mr. Willoughby Smith, was carried unanimously.

Resolutions were subsequently passed, after a good deal of discussion, fixing the price of the ticket to the dinner at 10s., providing for a guarantee fund to meet contingent expenses, and deciding upon the Holborn Restaurant as the place of reunion.

The following gentlemen were afterwards appointed an executive committee to make the final arrangements for the dinner:—Prof. Hughes, Messrs. Graves, Stroh, Spagnoletti, Siemens, Patey, and Preece.

Mr. F. H. Webb was appointed acting secretary, and Messrs. H. Alabaster and C. H. W. Biggs were elected honorary secretaries.

It was further resolved to entrust the musical arrangements to the executive of the Electro-Harmonic Society.

It may be mentioned for the convenience of those members of the general committee who were not present on Tuesday that the next meeting will be held, at the same hour and place, on Tuesday, July 4th, when it is expected that the sub-committee will present a final report of the arrangements.

Subjoined we give a list of the names of the

General Committee.—Sir Frederick Abel, C.B., D.C.L., F.R.S.; Prof. W. G. Adams, F.R.S; H. Alabaster, Sir James Anderson, W. S. Andrews, W. T. Ansell, F.R.G.S.; F. E. Baines, C.B.; Major C. F. C. Beresford, R.E.; C. H. W. Biggs, F.C.S.; John Bordeaux, Sir C. T. Bright, M.Inst.C.E., F.R.A.S.; E. B. Bright, M.Inst.C.E.; G. L. Bristow, Sir S. Canning, C.E.; W. Lant Carpenter, B.A., B.Sc.; G. von Chauvin, S. M. Clare, Edwin Clark, Latimer Clark, M.Inst.C.E.; T. R. Crampton, M.Inst.C.E; R. E. Crompton, William Crookes, F.R.S.; R. S. Culley, Charles Curtoys, F. Despointes, H. G. Erichsen, J. A. Fleming, M.A., D.Sc.; H. C. Fischer, Prof. G. Forbes, M.A., F.R.S.S. (L. and E.); John Fuller, F. E. Gatehouse, Charles Gerhardi, Dr. J. H. Gladstone, F.R.S.; Edward Graves, Robert K. Gray, Matthew K. Gray, J. H. Greener, Dr. J. Hopkinson, M.A., F.R.S.; Prof. D. E. Hughes, F.R.S; Gisbert Kapp, A.M.Inst.C.E.; H. R. Kempe, A.M.Inst.C.E.; J. C. Lamb, Louis Loeffler, Sir Henry Mance, C.I.E., M.Inst.C.E.; Admiral Mayne, R.C., C.B.; G. G. Newman, Jos. Oppenheimer, C. H. D. Patey, C.B.; W. H. Preece, F.R.S.; J. Radcliffe, Henry Sach, Sir David Salomons, Bart, M.A.; Alexander Siemens, Willoughby Smith, C. E. Spagnoletti, M.Inst.C.E.; Augustus Stroh, Prof. S. P. Thompson, D.Sc., B.A.; Sir William Thomson, LL.D., D.C.L., F.R.S.S. (L. and E.); H. P. Vernon, John Walsh, Henry Weaver, Major-General Webber, C.E, C.B. (late R.E.); L. Wells, T. H. Wells, E. T. Truman Wood.

H. Alabaster and C. H. W. Biggs, hon. secretaries; F. H. Webb, secretary.

The executive committee met on Wednesday, when the hon. secretary reported that the largest room—the Venetian room—at the Holborn Restaurant had been secured for the dinner, also two large rooms as reception rooms. It was arranged by the committee that circulars should be sent to all members and associates of the Society of Telegraph-Engineers, and to all gentlemen whose names and addresses could be obtained who had either in the past or present been connected with telegraphic operations. Other executive business was transacted.

[We may mention that the guarantee fund is open, and that the secretaries will be glad to receive additional names and contributions.]

LIGHTING WITH TRANSFORMERS AT ANTWERP.

Our Brussels correspondent writes as follows:—

"Some interesting experiments in electric lighting with transformers were carried out on the 18th inst. by the Société Industrielle d'Electricité, of Brussels, in the presence of a large number of notabilities. The guests were received by M. Beckmann, member of the Chamber of Representatives, and M. Dewalque, Professor at the Louvain University, both of them 'administrators' (directors) of the company, and M. Goffin, chief engineer, conducted the trials. These were in connection with a new central station to be established at Berchem-lez-Anvers, with transformers used under special and unusual conditions. This is the essential point of the system which is already working experimentally, but with success, in the shops of the Industrielle. The transformer adopted by this company maintains 500 lamps 5 kilometres (3 miles) off with a 4 millimetre wire. At Berchem the engines will be placed at a distance of 2½ kilometres (1½ mile) from the transformers. The main current of 1,000 volts is conducted from the dynamo to the exit poles of the *ensemble* of

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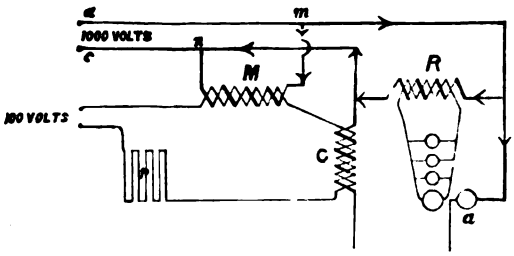
apparatus composing the system, passing through an amperemeter on one side, and on the other through an induction coil C (see diagram of installation at works), formed by a double winding round an iron core. Immediately after leaving the poles of the dynamo the main current is shunted at *m n* to a transformer M, which the inventors call a *Magnetiser* because it serves to produce a secondary current for exciting the machine. This current, issuing from the magnetiser, goes to the poles of the machine, entering the coil C at both ends, thus forming a *Compensator*. This double arrangement on the outside constitutes a hyper-compounding of the arrangement, and it is thus that so perfect an accordance is obtained of expenditure of current with the number of lamps in use. The exciting current also passes through an artificial resistance, *r*, variable by hand, which serves to regulate the initial intensity of the excitation, and to bring the machine to its normal *régime*. R is a small transformer, also in shunt circuit, which constitutes the *Reducer*, the office of which is to reduce the tension of the current, so that it may be measured by the ordinary appliances. It also affords the means of maintaining the lamps at the central station, which are in a secondary circuit. The other poles have shunt circuits to the three transformers at the end of the distance to be traversed, viz, at Berchem. Be it added that, by a similar arrange-



ment, another commune or district, near Antwerp, may be electrically lighted for 2¼ centimes per lamp per hour, while gas costs 3½ centimes per burner per hour."

CHUBB'S ELECTRIC SAFE ALARM.

We illustrate below a new safe alarm designed by Mr. N. G. Thompson, of Messrs. Thompson, Dowsing and Rew, for Messrs. Chubb and Co., the well-known safe manufacturers.

We are informed that Messrs Chubb and Co. had tried a somewhat similar arrangement some years previously, but it was found impracticable on account of the difficulty of obtaining a constant cell not requiring too much attention.

Mr. Thompson has, however, succeeded in minimising these objections by the introduction of his own battery, and by employing a galvanometer contact, the sensitive action of which has enabled him to employ a comparatively feeble current.

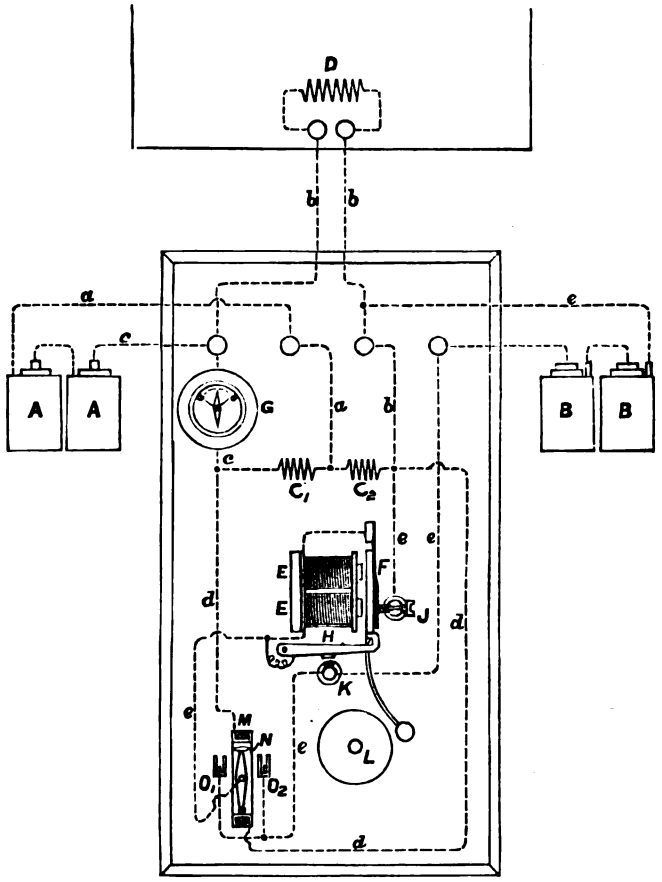
The object obtained by this alarm is that any two ordinary bell wires can be led from the safe to a bell-ringing apparatus in another part of the building, and although the wires may be exposed and secured to open terminals outside the safe it is impossible for anybody to tamper with them, either by cutting or bridging, without causing the bell to ring.

A series of contacts are also placed in and throughout the safe on the same circuit, so that if either the escutcheon be lifted, the door opened, or the safe removed, contact is immediately broken and the bell set in action. On reference to the drawing it will be seen that there are two batteries, the cells, A A, of the one being of the constant type referred to, and will maintain an even current for months, without any other attention than occasionally replacing the water and zincs in the inner vessels, whilst B B are ordinary Leclanché; CC_2 are two equal resistances, and G is a galvanometer, having a resistance approximating to that shown at D in the safe.

This galvanometer has a view needle, which shows when the current is on, and also indicates the condition of the constant battery. E E are ordinary bell magnets actuating the armature F, which supports or releases as the case may be the contact arm H. J and K are contact pillars, and L is a bell gong. M is also a galvanometer, having a vertically balanced needle, N, with platinum needle points attached to its upper end, the lower end being slightly weighted, and O_1 O_2 are mercury cups through which the needle points can dip, and so make contact. The contacts in the safe, the main switch, and the lever for replacing the arm H are not shown in the drawing. Prior to any disturbance in the safe circuit the current from the cells A A passes down the lead *a a*, and then divides through the two resistances C_1 C_2, and is conducted by circuit *b b* through the resistance D, and also by circuit *c c* through the galvanometer G back to the cells. The galvanometer M being in balance no current passes round it.

If, however, the circuit *b b* leading to the safe be cut, the galvanometer M will be thrown out of balance, and a current will be established through the circuit *d d*, which will cause the contact needle N to deflect, and so establish a momentary circuit by eKeJe on the bell battery, the consequent action being that the armature F is pulled towards the magnets E F, and releases the contact arm H, which short circuits the galvanometer M, and firmly establishes the bell circuit. The bell will then continue to ring till the arm H is again varied, the galvanometer needle having returned to its vertical position by reason of its weight.

If, however, the circuit *b b* leading to the safe is bridged at the terminals on the safe, or in fact anywhere, the galvanometer M is



again deflected, and the same results follow, by reason this time of a current passing in the opposite direction through the circuit *d d*.

A NEW MAKE-AND-BREAK TELEPHONE TRANSMITTER.*

What the action in the telephone transmitter is has been the subject not only of much controversy but of arduous research. The theory of Prof. Bell that articulate speech can only be transmitted by variations of a continuous current, *i.e.*, an undulatory current, has from the beginning been denied, and a number of forms of apparatus have been constructed to prove the contrary. These "make-and-break" telephones, as they are called, have, as a rule, been so constituted that the makes and breaks are effected by the action of the sound waves impinging against a diaphragm to which the contact point is attached.

In order to make the action of the make and break entirely clear Mr. Stephen D. Field and Mr. Rudolph Eickemeyer have recently constructed a telephone transmitter in which the transmitting points are not in contact when the instrument is at rest.

The instrument is, in fact, an automatic circuit breaker, which automatically makes and breaks an electric circuit with a rapidity too great for its effects to be appreciated by the ear. A diaphragm is then arranged so that sound waves projected against the same are caused to bridge over more or less of these makes and breaks of the circuit in proportion to the rapidity with which the sound waves succeed each other.

The instrument, which is decidedly novel in many respects, is shown in Fig. 1. The diaphragm M supports a platinum contact point G. The mouthpiece Z is attached to the front of the instrument, and sound waves entering strike against the diaphragm M

* From the *Electrical World* of New York.

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carrying the contact G. The contact point E is cushioned against a soft rubber cushion, *e*, which is of spherical shape, and is provided with a perforation, through which the fine wire C passes for attachment to the contact piece. The wire also passes through a hollow screw, *j*, which is set into the head of the telephone, and an adjusting screw O regulates the tension upon the rubber cushion through the wire C. The apparatus also comprises the usual battery B and induction coil H, together with a switch.

It will be seen that the circuit of battery B passes normally through the insulated metallic frame J of the telephone and the wire C to the contact E. It will also be observed that there is a short circuit by way of wire I between the contact point G and the frame J. The tension of the wire C is normally sufficient to separate the points E and G. When, however, the switch A is closed, and the cuirent from battery B passes over wire C, the latter will heat and expand, and allow the points to come into contact. The current will thus be shunted around the wire C through a path of approximately no resistance, and as a result, the fine wire, becoming cool, will contract and separate the contact points. The apparatus thus becomes a circuit breaker, working with almost inconceivable rapidity so long as the current from the battery B continues to circulate. The makes and breaks are so rapid as to pass beyond the limit of receptivity of the ear.

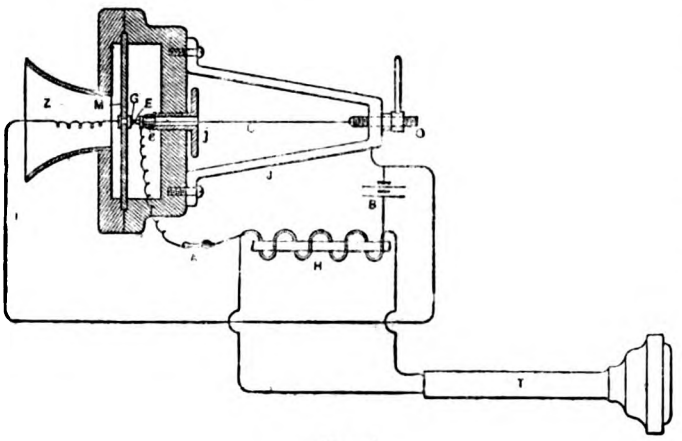

FIG. 1.

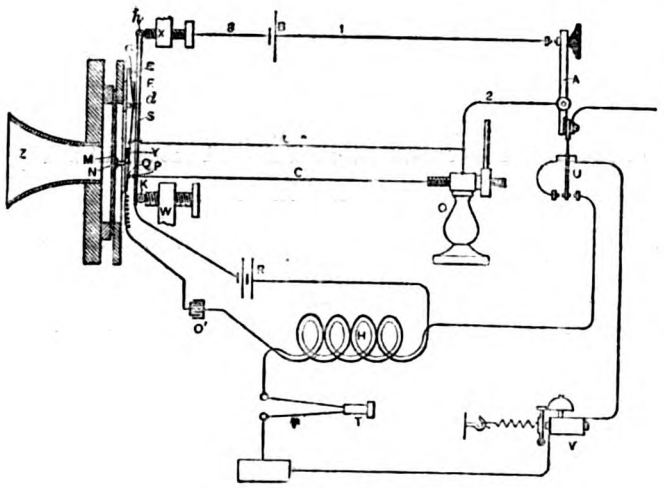

FIG. 2.

Now, it is evident that sound waves striking upon the diaphragm M will alter the relative positions of the points E and G, tending to prolong their respective contacts. These prolonged contacts will produce effects which are audible, and if they follow each other in the proper sequence articulate speech will be transmitted and reproduced in the receiving instrument.

The object of the cushion *e* is to render the apparatus more sensitive as regards the action of the wire C in response to successive heating and cooling.

The cushion forms a sufficiently rigid home for the contact G, and is at the same time sufficiently yielding to respond quickly to the expansion and contraction of the wire C. The diaphragm M is an insulating diaphragm of wood.

In another form of apparatus embodying the same principle, and shown in Fig. 2, the points E and G are supported respectively upon levers S and F, the former being pivoted at *h* and the latter at *d*. The relations of the two levers can be adjusted by means of the screws W and X, the former of which bears against the lever S at one end and the latter against the rubber spring K, which is located between the other end of the lever and the screw W. The circuit of battery B in this apparatus, when the key A is closed, passes by way of wire 1, key A, wire 2, adjusting screw O, and fine wire C to the lever S and back to the battery by way of the screw X and the wire 3. The closing of the key will therefore cause the current of battery B to pass through the wire C, thus heating and causing it to expand. The wire will accordingly be lengthened, and the tension upon the lever S will be relaxed, allowing it to move towards the lever F by reason of the pressure exercised upon it by the rubber spring E. If this lever movement continues far enough, the points E and G are brought into contact, closing a short circuit around the wire C. The short-circuiting of the wire C will cause it to cool and contract, and thereby break the contact between the points E and G, whereupon the above operation will be repeated automatically as long as the key A is kept closed. A sound wave striking upon the diaphragm M will therefore tend to cause a separation of the contacts E, G, and to prolong the expansion of the wire C. Now, the lever S carries besides the contact point E a point, P, which is located exactly opposite a similar point, Q, on the lever F. The action by which the movements of the diaphragm tend to prolong the expansion of the wire C will accordingly tend also to prolong the contacts of the points P and Q when the latter is moved towards it by a movement of the diaphragm due to the effects of a sound wave. The condenser O' is included in the battery circuit to prevent sparking.

By employing a thin diaphragm, and sealing up all the works in a heavy cast-iron box to cut off outside vibrations, the apparatus may easily be made to serve as a telephone repeater. The diaphragm is then arranged with an electro-magnet in proximity to it, the magnet being included in the line over which impulses are being sent.

The idea embodied in the invention is that the fine wire C, with its connected contact point, forms an automatic circuit-breaker whose makes and breaks produce no audible effects upon the circuit, by reason of the great rapidity with which they follow each other. That is to say, the normal vibrations of the circuit-breaker, considered with respect to their capacity to reproduce sounds, are neutral or inharmonious. That which reduces them to harmony and enables them to reproduce sounds in a receiving instrument are the devices which bridge over or throw together more or fewer of the inharmonious vibrations and thus alter their natural sequence.

A FEW COMPARATIVE STATISTICS OF ELECTRIC RAILWAYS.*

BY T. COMMERFORD MARTIN.

It is not now my intention to present a paper on the general subject of electric railways. That I did at a meeting of the Institute held last December, when I was enabled to offer a few statistics on the electric railway as compared with horse, cable, and other methods of traction for street cars. I have found since then a great desire generally for information as to the status of electric roads in the United States and Europe. Street railway men, investors and others have wished to know whether such a thing as an electric road was really operating anywhere or not, and, if the lines were running, what the cost of construction and operation was. The tables I submit herewith are intended as an answer to those queries. It has been difficult to get at a common basis of estimate and statement. With regard to the European roads, I would say that I have been greatly indebted for the figures to a most admirable and exhaustive paper, read a few weeks ago by Mr. Reckenzaun before the London Society of Arts. In Europe, as here, various systems of transmitting the current and of connecting up the motor with the car axles and wheels are in use, and as yet no determination as to the best method seems to have been reached.

Respecting the figures for this country, I would say that they are necessarily very much in the shape of an estimate as to the number of passengers; though, by allowing each car only 50,000 passengers a year—merely 150 a day—my calculations come out as rather low. The facts may be summed up by saying that in Europe the electric railways are now carrying passengers at the rate of 3,000,000 annually. In America they are carrying at the rate of over 3,500,000, and when the roads now building are finished—to say nothing of the scores for which contracts are being made—the number carried will be at least 7,000,000 annually. When the roads at the places I enumerate in the tabular foot-notes all go into operation, the number will be easily quadrupled. As to cost, I would remark that in every instance yet brought to notice, electricity has spelled economy. I saw recently some authentic and

* Paper read before the American Institute of Electrical Engineers, May 18th, 1887.

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ELECTRIC RAILWAYS IN EUROPE, APRIL, 1887.

Place.	Length.	Motors and Motor Cars.	No. of Passengers.	Freight.	Total Expense of Operation.	Car Miles Run Yearly.	System of Conductors.	Prime Power.
Lichterfelde-Berlin, 1881	1½ miles	2	100,000 yearly	.....	.....	.....	All rail	Steam engine.
Brighton, 1883	1 mile (single track)	2	1,000,000 total	.....	1·92 pence per car mile ...	46,950	All rail	Gas engine.
Moedling-Hinterbruehl, 1884	2·8 miles (single track and sidings)	12	340,000 yearly	.....	3·42 pence per car mile ...	91,002	Overhead slotted tubes	Steam engine.
Frankfort-Offenbach, 1884	4·1 miles (double track)	14	990,000 yearly	.....	3·83 pence per car mile	292,269	Overhead slotted tubes	Steam engine.
Zankerode (mine) 1882	790 yds. (double track)	1 locom. 16 waggons	.....	300 tons daily	·77 penny per ton	660 waggons daily	Overhead inverted ⊥ rails	Steam engine.
Hohenzol'ern (mine) 1884	820 yds. (double track)	1 locom. 15 wagons	.....	300 tons daily	·5 penny per ton	6·0 waggons daily	,, ,, ,,	Steam engine.
Portrush, 1883	6 miles (single track)	4	Over 100,000 up to 1885	.....	2½ pence per car mile	.....	Third rail	Water power.
Besspool, 1885	3 miles (single track)	8	300 000 yearly	30,000 tons yearly	4 pence per train per mile	60,000 train miles yearly	Third rail	Water power.
Blackpool, 1884	2 m. (single & dble. track)	10	Over 1,000,000 total	.....	Less than 4 pence per car m.	.....	Conduit	Steam engine.
Brussels, 1887	.....	5	.....	.....	.....	.....	Operated by storage batteries	.....
Hamburg, 1886	.....	2	.....	.....	.....	.....	Operated by storage batteries	.....

NEW ROADS.—A special charter has been granted by the Austrian Government for a road in the Austrian Alps, to cost about $350,000, and to be 15 miles in length.
A road is being built in the great salt mines at Stassfurt, Germany.
The North Metropolitan Tramway Company, in London, has several motors now ready for use with storage batteries on its line, awaiting powers from Parliament.

ELECTRIC RAILWAYS IN AMERICA, MAY, 1887.

PLACE.	Length.	Motors and Motor Cars.	No. of Passengers.	Freight.	Expense of operation.	Car Miles Run.	System of Conductors.	Prime Power.
*Baltimore, Md., 1885	2 miles, single track with turn outs	6	260,000 yearly	.....	$4 per car per day.	Each motor runs 73 miles daily	Third rail and overhead wire	Steam engine
*Los Angeles, Cal., 1887	3 miles, single and double	8	200,000 yearly	.....	.....	.....	Single and double overhead wire	Steam engine
*Port Huron, Mich., 1885-6	4 miles, single track	8	275,000 yearly	.....	.....	.....	Single overhead conductor	Steam engine
*Windsor, Can., 1885	Nearly 2 miles, single track	2	200,000 yearly	.....	$4 per day for power.	64 miles each car per day	Single overhead conductor	Steam power from electric light station
*Highland Park Detroit, Mich., 1886	3½ miles, single track	2	200,000 yearly	.....	80 cents per day for fuel	Each runs 13 hours daily; capacity, 30 passengers; speed, 15 m. an hour	Sunken central rail	Steam engine
*Dix Road, Detroit, Mich., 1886	1¾ miles, single track	4	300,000 yearly	.....	.....	The trains run from 6 a.m. to 11 p.m.	Double overhead conductor	Steam engine
*Appleton, Wis., 1886	4½ miles, single track and double	8	400,000 yearly	.....	For power, wages of one man as they own their own water power	17 hours daily	Double overhead wire	Turbine within wheels
*Scranton, Pa., 1886	3½ miles, single track, four sidings	3	300,000 yearly	.....	$9 per day for power, but are putting in their own engine	Each car runs 85 miles per day	Overhead wire	Steam power from electric light station
Denver, Col., 1886	3½ miles, single and double	7	500,000 yearly	.....	$1.50 per day for fuel	.....	Conduit for series system	Steam engine
Montgomery, Ala., 1885-6	11 miles, single and double	18	This ran 2 cars one year. Have just started other cars (1,000,000 yearly)	.....	Fifty per cent. less than horse and mule traction—General Manager's report	.....	Overhead conductor	Steam engine
†Kansas City, Mo.	.....	.....	.....	.....	.....	.....	.....	.....
Orange, N. J., 1887	½ mile built	1	.....	.....	.....	.....	Overhead conductor	Steam engine
Boston, Mass. (sugar refinery), 1887	Short track within the works	1 locomotive, 3 cars	.....	The cars in constant use all day; the loads averaging 10 tons per trip, and each round trip averaging 5 minutes.	.....	.....	Overhead conductor	Operated from the lighting dynamo

* Extending line or increasing rolling stock. † No specific details received, line not being yet in regular operation.

NEW ROADS.—Electric railways are now in course of construction, or under contract, at Pittsburgh (3 roads); Los Angeles; Binghamton, N. Y., 4½ miles, 8 motor cars; Lima, O., 3 miles, 6 cars; San Diego, Cal., 9 miles, four 40 horse-power motor cars; Ansonia, Conn., 3½ miles (water power); New York city (for Fulton street); St. Joseph, Mo., 20 cars; Mansfield, O.; Ithaca, N. Y.; Harrisburg, Pa.; Woonsocket, R. I.; Richmond, Va., 40 cars, 11 miles of track.

Companies have been formed or steps taken to build and operate electric roads at Flushing, L. I. (2); Lincoln, Neb.; Brookline, Mass. (2); East Cambridge, Mass.; Newton, Mass.; Boston, Mass.; Asbury Park, N. J.; Pelham Park, N. Y.; New Brunswick, N. J.; Plainfield, N. J.; Bayonne, N. J.; Worcester, Mass.; Scranton, Pa.; Carbondale, Pa.; Philadelphia, Pa.; Reading, Pa.; Bangor, Me.; Biddeford, Me.; Westfield, Mass.; Chicopee, Mass.; Muncie, Ind.; Gratiot, Mich.; Tiffin, O.; Cincinnati, O.; Brooklyn, N. Y.; Coney Island, N. Y.; Rockaway, N. Y.; Winston, N. C.; Jacksonville, Fla.; Pensacola, Fla.; Birmingham, Ala.; Selma, Ala.; Atlanta, Ga.; Fort Smith, Ark.; Wichita, Kan.; San Francisco; San Jose, Cal.; Newton, Kan.

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extremely elaborate statistics for 1879 of street railways and their cost in New York and Brooklyn. They were taken from the various official reports. The showing for the total cost of operation per car ranged between $8 and $10 per day at that time. The saving on that with electricity is, according to circumstances, at least 25 to 40 per cent. with heavy traffic.

A PRACTICAL TEST OF STORAGE BATTERIES FOR TRAMWAYS.

In a paper read before the Electrotechnischer Verein, at Berlin, Herr J. L. Huber, the engineer of the Hamburg street railway, gives some very interesting details regarding the cost and operation of storage batteries on street railway lines. The system employed by Herr Huber is the Julien, in which the storage batteries are carried by the car.

In order to obtain reliable results, experiments were undertaken on a specially difficult line, both as regards curves and grades, and which, in addition, crossed much frequented streets, so that all the difficulties met with in railroad traffic in populous cities were encountered. The road extends from the Rathhausmarkt, in Hamburg, to the Berthastrasse, Barmbeck, over the Mühlendamm, on which line grades of 30 per cent. are encountered.

Herr Huber states, regarding the durability of the E.P.S. storage battery employed, that deterioration takes place only in the positive plates; and this is the more pronounced the greater and more frequent the normal strength of current for which the plates are designed is exceeded. With a well-regulated management—that is, by an arrangement of storage batteries and car, such that with the heaviest grades and loads no abnormal current is drawn from the battery—the wearing out of the positive plates amounts to from 2 to 3 per cent., or, in round numbers, $2\frac{1}{2}$ per cent. for 1,000 kilometres travelled. If, in addition, the traffic be so arranged that with every charge of the accumulators only 50 per cent. of the distance is travelled which could be travelled with new plates, then a wearing out of the plates amounting to 50 per cent. is permissible—that is to say, that over 20,000 kilometres (12,500 miles) can be run before renewal becomes necessary. A car which, including passenger and storage batteries, weighs 7,000 kilogrammes (about 7 tons), and which is to ascend grades of 30 per cent., such as occur on the Hamburgh line, requires 800 kilogrammes of active material in the positive plates, and its renewal, including the cleaning of the grids, which can be used over again, as they are not oxidizable, costs 1s. per kilogramme (2·2lb.)—that is, 4 pfennigs ($\frac{1}{2}$d.) per kilometre run. That would be 0·8d. per car mile for renewal of plates.

Under the same conditions the motive power required is $\frac{3}{4}$ horse-power hour per kilometre ($\frac{3}{8}$ mile) run. The cost for attendance, oil, maintenance, &c., for one-horse power hour is 1d.; consequently this cost per car kilometre is $\frac{3}{4}$d. To the above items must be added the maintenance, oil, &c., for the motor on the cars, which amounts to $\frac{1}{4}$d., and contingencies run up to an additional $\frac{1}{4}$d. The total cost, therefore, with the conditions given amounts to $1\frac{1}{4}$d. per car kilometre (2·8d. per car mile) or $\frac{1}{4}$d. per tonne kilometre ($\frac{1}{4}$d. per ton mile).

Comparing the cost of electrical traffic with that of horses, Herr Huber states that to operate the usual one-horse car, which, including driver and conductor, carries 26 persons, 7 horses are required on the same line for one day of 100 kilometres run. So that, as the electric car carries 31 persons, $8\frac{31}{100}$ horses would be necessary. The cost of maintenance for one horse during the last year, according to the *Jahresbericht der Strassen-Eisenbahn-Gesellschaft*, Hamburgh, amounted to 1·96s. per day per horse; so that the cost per car kilometre amounts to 2d. (3·2d. per car mile). It follows, therefore, that even to-day electricity is more economical than horseflesh, and the cost of the former can be considerably reduced by improvements.

The results of experiments show that 88 per cent. of the energy stored in the accumulators can be drawn out, and Herr Huber only counts upon 80 per cent. for safety; that is to say, that of the electrical energy delivered by the dynamos 20 per cent. is lost by the use of accumulators, and this is independent of the length of the line and the power required upon the same, such as the overcoming of grades, &c. It is to be remarked, also, that for the electric traffic such as exists in Hamburg, any car driver can be employed and no trained men are necessary, as is the case with locomotives, so that the expense of trained hands is avoided.

The above are the results of experiments which were carried out from the end of May to the end of December of last year, with a public passenger car, and the distance travelled amounted to 12,000 kilometres (about 7,500 miles). As these experiments were undertaken in public traffic on an ordinary horse road made specially difficult by its grades, and not upon a road specially constructed for the purpose, Herr Huber is of opinion that the life and power of competition with other systems of the storage battery is definitely assured.

THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION, AND CAPACITY.

BY W. E. SUMPNER, B.SC.

(Continued from page 150.)

Maxwell's absolute method being thus equally applicable to the measurement of self-induction, mutual induction, and capacity, it seemed very probable that any method of measuring either of these quantities would suggest methods of measuring the remaining two. For that purpose I have traced out an analogy, which is represented in the figures. The first twelve figures show the result of the analysis of Maxwell's methods. The next six figures (13—18) represent the result of an analysis of Fleeming Jenkin's method of determining the capacity of a condenser. Figs. 13, 14, and 15 represent analogous methods of determining the self-induction of a coil, the mutual induction of two coils, and the capacity of a condenser. The coil or condenser is charged by making the battery connection, and discharged through the galvanometer. In the case of mutual induction the alteration of the current in the battery circuit causes a quantity of electricity to rush through the galvanometer, which is a measure of the product of the change of current and the mutual induction. In each case it is necessary to determine the meaning of the swing of the galvanometer, and to eliminate the unknown electromotive force of the battery. This can be done by the same method in each case.

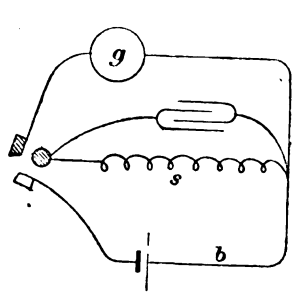

Fig 13.

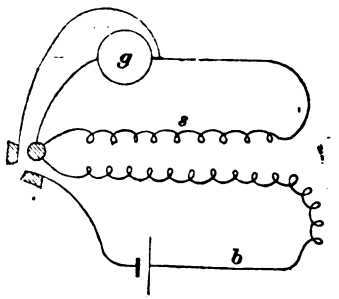

Fig 14.

If, however, the battery and galvanometer connections are made and broken periodically the effects are accumulated, and the galvanometer will give a steady deflection, which, on being compared with the deflection given by the same galvanometer and battery when a known resistance is in circuit, will render it possible to determine the required coefficient directly in terms of the resistances used, the ratio of two deflections, and the period of the commutator cycle. A ballistic galvanometer may therefore be dispensed with. In the method indicated by Fig. 13 a short interval may be allowed to occur between breaking the battery connection and making the galvanometer connection, provided a condenser be used. It is, however, better to dispense with a condenser, and allow a short time to elapse between making one connection and breaking the other, for when the coil having self-induction is suddenly isolated its electro-kinetic momentum will cause the potential difference of the condenser shunted to it to alter almost instantly to many times its original value. In either case, however, a correction will have to be applied to the formula. In the method of Fig. 15 an interval may with advantage be allowed to occur between the breaking of one connection and the making of the other. In the method of Fig. 14 it is advantageous to make the connection which short-circuits the galvanometer before breaking the battery connection.

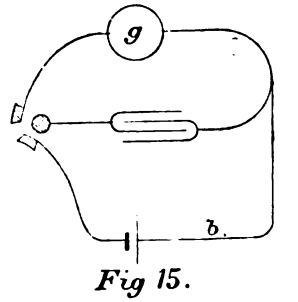

Fig 15.

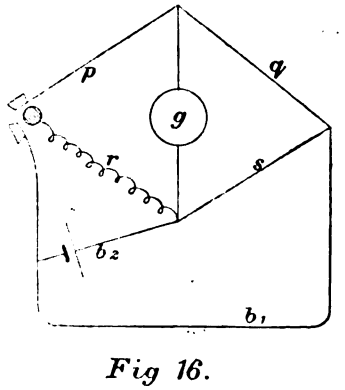

Fig 16.

As, however, the effect of accumulating all the impulses in one direction is, as far as galvanometers are concerned, to produce steady currents, it is easy to develop these methods into null methods. We have only to shunt part of the battery current continuously through the galvanometer. Figs. 16, 17, and 18 show the result. The battery has to be placed differently in Figs. 16 and 18, because a condenser discharges in the opposite way to that of a coil having self induction. A particular case of Fig. 18 is when the resistance R shunting the condenser is made infinite. If we suppose the self-induction of the wire R to increase, and the capacity of the condenser to diminish, the effect on the galvanometer due to the induction diminishes through zero till, in the limit when the capacity of the condenser is nothing, we have merely the case of Fig. 16. The remarks

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about the commutators of Figs. 13, 14, and 15 apply equally to those of Figs. 16, 17, and 18. In Fig. 17 it is seen that the commutator develops into that used by Profs Ayrton and Perry.

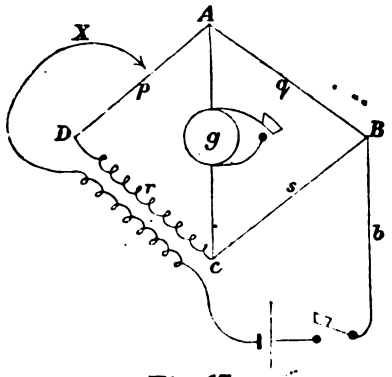

Fig 17.

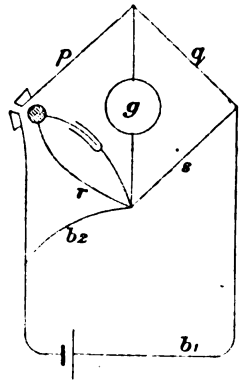

Fig 18.

In seeking the method of measuring mutual induction analogous to the methods of Figs. 16 and 18, it was found that the end X (Fig. 17) of the battery branch could be placed at any point on the bridge along A D C. Now, if the point X be connected with D, we have Maxwell's method; while, if it be connected with C, we have a simple deduction from Prof. Carey Foster's method when we accumulate, since, under these circumstances, it is easy to see that the condenser used by Prof. Carey Foster is needless. There is consequently a close relationship between all these methods, and no one of them is distinct.

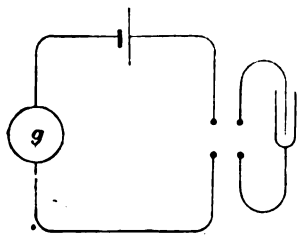

Fig 19.

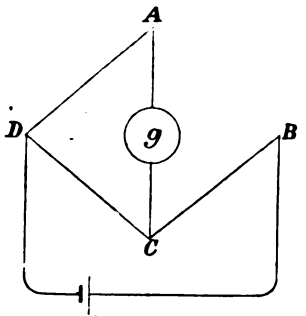

Fig 20.

Figs. 19—21 show methods for finding capacity and self-induction which are analogous with a method given by Maxwell (Vol. II., sec. 776). Fig. 20 represents a Wheatstone bridge in which one of the arms A B is absent, and this absent arm may be supplied by any one of those represented in Figs. 20a to 20f. Figs. 19 and 20a represent Maxwell's method of finding capacity (Vol. II., sec. 776)—a method to which he was led by the consideration that if the connections of a circuit with the terminals of a condenser were periodically interchanged, the effect of the capacity would be comparable with that of a resistance. The same analogy led to a method of finding self-induction described in the appendix of the paper of Profs. Ayrton and Perry, and represented in Figs. 20e and 21. The difference between the two cases consists in the fact that the more rapidly a condenser is commutated the less is its apparent resistance, while the reverse is the case with self-induction. In Fig. 20a, if the resistance Q of the self-induction coil increases without limit, we have simply Maxwell's method, in which an interval between the reversals

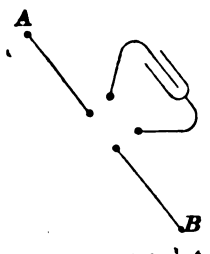

Fig 20a

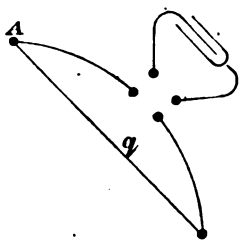

Fig 20b

is advantageous. If, on the other hand, there is no condenser used, a small short-circuit may be allowed to occur during reversal, and its effect eliminated in the way described in the appendix of Profs. Ayrton and Perry's paper. Prof. J. J. Thomson (*Phil. Trans.*, III., 1883) gives a modification of Maxwell's method, which consists of breaking the condenser connection and discharging it, instead of reversing its connections. In Fig. 20c much the same result is brought about by employing a revolving connector, which short-circuits the condenser during a small fraction of a revolution. The formula will have to include a correction for the short-circuiting the arm A B of the bridge while the condenser is being discharged; but this correction need be but very small, for the time constant of the condenser for discharge, being the product of its capacity and the resistance of the short-circuit, is very small indeed, so that the short-circuiting need only last for a very small fraction of a revolution. Figs. 20b and 20d are but extended cases of Figs. 20a and 20c. Maxwell's method may be regarded as a special case of the method represented in Fig 20e. Fig. 20f represents a method of finding self-induction somewhat analogous with that of Fig. 20c, but it has not yielded good results. There are analogous methods of determining mutual induction, but they are not very promising. In these methods the commutator is in the arm of the bridge. This is no disadvantage in the case of measuring capacity, but it is a disadvantage in the case of self-induction unless the resistances of the bridge are much larger than that of the commutator. The connection of these methods with the preceding is shown by Fig. 18. If, instead of discharging the condenser through the galvanometer, the condenser be charged through the galvanometer, we get Prof. J. J. Thomson's modification of Maxwell's method.

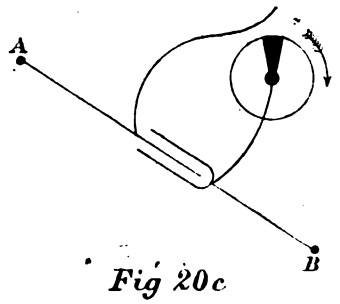

Fig 20c

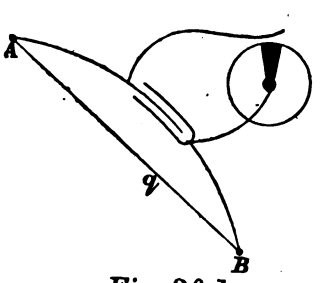

Fig 20d

Fig. 22 represents a method suggested by Prof. Ayrton for determining the coefficient of self-induction of a coil while a particular current is flowing through it. It is but a slight modification of Maxwell's method, and consists in altering by a small amount the current running through the bridge instead of establishing it from zero to its full value. It can be easily shown under the circumstances that

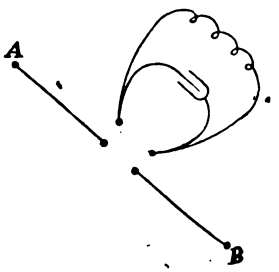

Fig 20e

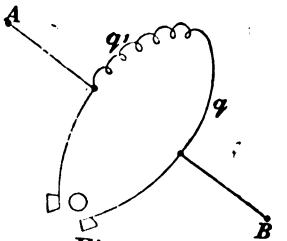

Fig 20f

$$L = \frac{C_1}{C_1 - C_2} \times \frac{\sin \frac{1}{2}\theta}{\tan \alpha} \sqrt{\frac{RT}{\pi^2 + \lambda^2}}\, e^{\frac{\lambda}{\pi} \tan^{-1} \frac{\pi}{\lambda}}$$

where C_1' is the current running through the coil when a derangement R of the arm of the bridge in which the coil is placed produces a steady deflection α on the bridge galvanometer, and $C_1 - C_2$ is the change of current in this arm which, when the bridge is balanced for steady currents, produces a swing θ; T is the period and λ the logarithmic decrement of the same galvanometer.

The experiments, which were performed with the aid of Messrs. Rossiter and Watney, of the Central Institution, were made on the field-magnets of a Gramme dynamo, and also on those of a Ferranti dynamo. The arms A B and A D had resistances of about 10,000 ohms each, B B_1 was the coil whose self-induction was required, D D_1 was a German silver wire of about equal resistance, D_1 D_2 was a very thick German silver wire on which a sliding connector (C) was placed. The D'Arsonval galvanometer G_1 connected A and C through a key. The mercury cups B_1, B_2, were connected by a short-circuit plug, except when the deflection corresponding to known derangment R of the arm B C was required; *a a a* are accumulators, *r r r* is a resistance capable of being inserted more or less into the battery circuit by means of the switch *s*. The currents were changed by moving the switch, and the change of current was read by a second D'Arsonval gal-

Fig 21.

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vanometer (G_2). By pressing the key K_1 the galvanometer G_2 was shunted to a constant length of the wire $D_1 B_2$, and measured the current absolutely. By pressing the key K_2 the galvanometer was shunted to any convenient length of the wire $D_1 B_2$, and by taking the deflections corresponding with C_1' C_1, and C_2 the ratio $\frac{C_1'}{C_1 - C_2}$ was easily found.

The currents used varied up to 30 amperes, and were sent in both directions. The results show that the coefficient varies with the current, and also with the previous history of the iron. The set of values obtained with an ascending series of currents differs from that obtained with a descending series. The coefficient diminishes rapidly at first, and then more and more slowly. In several cases the results strongly indicate that the maximum value of the coefficient is not that for zero current. This is exactly what it is natural to expect, on the assumption that the self-induction curve is the differential of that of magnetic permeability; for the slope of the latter curve is small at first, increases to a maximum, and then diminishes asymptotically. All the results are, however, much complicated by the fact that the D'Arsonval galvanometer was not sufficiently ballistic. Under these circumstances changing the resistance in the battery circuit alters the time constant of the bridge, although it does not for the same change of current alter the quantity which passes through the galvanometer. The ratio between the swing of the galvanometer and the quantity passing through it was therefore not constant and the results are therefore not accurate.

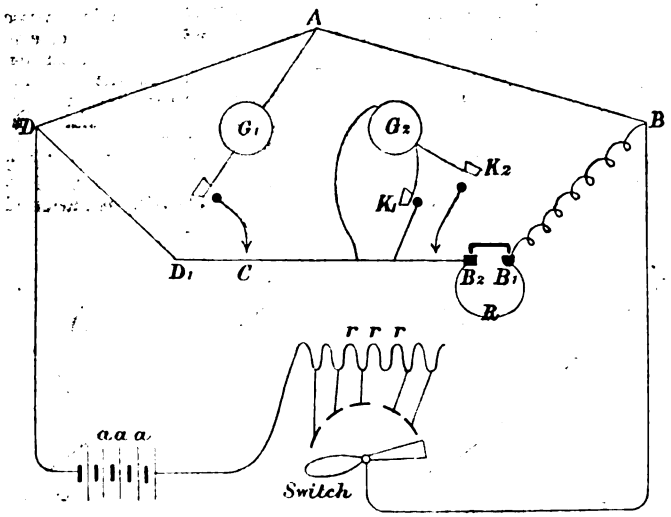

Fig 22.

This method is equally applicable to the measurement of change of coefficients of mutual induction and capacity. It is not easy to render it accumulative. If, instead of making and breaking the battery circuit, the points B and D be periodically shunted and unshunted by a known resistance, it would be necessary to know the resistances in the other parts of the bridge; and this would be difficult if the resistances heat, as they must when large currents are used. In the method just described the only resistance necessary to know was that of R, and this was not allowed to heat.

(*To be continued.*)

PHYSICAL SOCIETY.—June 25.

Mr. Shelford Bidwell, F.R.S., Vice-President, in the chair.

The following communications were read:—

Note on Magnetic Resistance. By Prof. W. E. Ayrton, F.R.S., and Prof. J. Perry, F.R.S.

In the spring of 1886 the authors made experiments on the magnetic induction through horseshoe electro-magnets when excited by constant currents. The inductions through different armatures and air spaces were also measured. The results show that for small exciting powers the law of parallel resistances is true for magnetism, taking leakage into account. From experiments made with two electro-magnets, the poles of which were placed at different distances apart, the authors conclude that the magnetic resistance of air is proportional to length, or to length plus a constant A "Note on Magnetic Resistance" was read before the Society on the 12th March, 1887, by the same authors, describing experiments on two iron rings, one whole and the other divided by a radial saw cut. Since then the experiments have been repeated with great care by Colonel Swinton and Mr. Sorenson, of the Central Institution. The resulting curves agree with those previously obtained. On measuring the air space it was found considerably less than estimated, and the magnetic resistance of air relative to iron (assuming no "surface resistance") comes about 1,500. Experiments made with different air spaces together with the above seem to show a considerable surface resistance. Prof. S. P. Thompson thought dynamo makers had evidence of such "surface resistance" from the care exercised in avoiding joints in the magnetic circuit wherever possible, and Mr. Bosanquet mentioned some experiments he had recently made on the resistance of joints during the various stages of fitting. The changes of resistance are very large, and he concludes that however good the fit it is not possible to reduce the "surface resistance" to a negligible quantity.

On Sounding Coils. By Prof. W. Stroud, D.Sc., and Miss J. Wertheimer, B.Sc.

The paper describes experiments in coils and helices of wire, which emit sounds when variable electric currents are passed through them. The pitch depends on the frequency of the current variations. The authors believe the sounds due to the attractions of adjacent parts of the wire, which cause shortenings and lengthenings as the current increases or decreases. To prove this, two identical coils were made, and one of them embedded in plaster of Paris. This gave no sound when the variable current was passed, whilst the other emitted the usual note. It was also found that no sound could be got from a single turn of wire, whilst one and a-quarter turns gave an audible sound under the same conditions.

On Comparing Capacities. By Mr. E. C. Rimington.

This is an investigation of the conditions under which the integral current through a galvanometer in a balanced Wheatstone bridge is zero, when the battery circuit is broken, two adjacent arms (A and D) of the bridge being shunted by condensers of capacities K_1 and K_2. It is shown that $\frac{K_1}{K_2} = \frac{C}{B}$, where C and B are the resistances of the arms opposite to A and D respectively. If A and D be made infinite the necessity of balancing for steady currents is obviated, but if either of the condensers has an appreciable leakage corrections are required. The best resistance to give to the galvanometer is shown to be $G = \frac{B(C+D)}{B+C}$, and the conditions under which a telephone may replace the galvanometer are $\frac{K_2}{K_1} = \frac{C}{B}$. The case where all the arms have self-inductions is investigated.

On Permanent Magnet Ammeters and Voltmeters of Invariable Sensibility. By Profs. W. E. Ayrton, F.R.S., and J. Perry, F.R.S.

The sensibility of ordinary permanent magnet ammeters and voltmeters increases as the strength of the magnet decreases, whereas in those of the Depretz-D'Arsonval type (in which a suspended coil controlled by torsion swings between the poles of a permanent magnet) the reverse effect takes place. By continuing the two systems the authors have devised instruments whose sensibility is unaltered by changes in the strength of the magnet. The torsional control of the D'Arsonval is removed and a small permanent magnet attached to the swinging coil. As the large permanent magnet changes the controlling and deflecting forces change in the same proportion, and the deflection for a given current remains unaltered.

COMPANIES' MEETINGS.

South of England Telephone Company (Limited).

The third ordinary general meeting of this Company was held on Tuesday last, at Winchester House, Old Broad-street, under the presidency of Mr. D. Owen Bateson.

The Secretary (Mr. Fred. L. Robinson) having read the notice convening the meeting, the report of the Directors was taken as read.

The Chairman said: When I last had the pleasure of seeing you I told you that I expected in future to produce our accounts within six weeks of the termination of our year, which ended 30th April. Our report is dated 16th June, so I think I was not far out in my calculation. I have no doubt but that you have scrutinised the figures that have been presented you, and in your own minds have criticised them. Your Directors consider that under the circumstances they are fairly satisfactory, and I trust you will do the same. Up to nearly the end of the past year we had every reason to be pleased with our progress, and we felt sure that a dividend of 1 per cent. at least would be earned on our ordinary shares. The disastrous storm of the 26th December, in levelling our wires and poles, dashed to the ground all our hopes. Those of you who saw the state of the London streets on the memorable morning of the 27th December can form a very good idea of the condition of our system in most of our centres. It was really an utter collapse in Reading, Northampton, Cambridge, Oxford, Colchester, Ipswich, and Norwich and partially in other places. Fortunately, however, our southern stations were hardly touched, and Brighton and our south coast exchanges did not suffer at all. Well, gentlemen, we set about repairing the damage as quickly as possible, and some of our lines were got into working order pretty quickly. But the main part took a very long time, not so much from the difficulty in running the new lines—though the scarcity of good workmen did in a measure delay us—as the withdrawal of our way-leaves, which hampered us very seriously. The main result was a total loss of fully three months of our existence, as we had to postpone the payment of our rentals quite this time. And even this does not tell the whole story. Our new orders almost ceased entirely in the damaged district during the time of reconstruction; and this was a serious matter, as previously orders to the extent of from £400 to £500 per month were coming in. The total cost of the disaster it is impossible to estimate; but you will notice that we have placed £1,365. 3s. 7d. to debtor of the account, which merely represents our out of pocket expenses. After all, the collapse must not be considered as an unmixed evil, as it taught us a great deal in the way of construction, and we think we have made our system much more secure by adopting pole routes—ground poles where possible—and by avoiding chimney attachments as much as we can. I think it will

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be found to be so, and that we shall never again have to record a similar disaster, or anything like it. During the year our exchange lines have increased 443, and private lines 100, against 571 and 125 respectively in 1886; and our gross rentals are £11,487, against £7,809 in 1886, showing an increase of £3,678. You will remember that last year's balance-sheet included fifteen months' working, this year only twelve, and from this we must deduct at least three months' loss of time, occasioned by the disaster I have alluded to. Though our progress has not been by leaps and bounds it has been steady and continuous. Your Directors look on the accounts as, under the circumstances, being satisfactory. They have during the past year been engaged rather in developing their old centres than in establishing new ones. We have found it for the convenience of our subscribers in contiguous towns having business relations with each other to connect them by trunk lines; thus Norwich and Yarmouth can speak to one another, and it is not unlikely but that Lowestoft may also be connected with these two exchanges, if we meet with sufficient encouragement to undertake the expense. Northampton and Wellingborough, and Folkestone and Dover are connected, as also Chatham and Maidstone. We are now canvassing for way-leaves between Brighton, Lewes, and Eastbourne, as also between Brighton and Worthing, and we shall proceed with other lines as the demand for them arises. The district in which we work is not a very promising one as regards business. We have few large towns, Brighton being our largest. I may say we have no manufacturing or commercial centres to compare with Bristol, Birmingham, Liverpool, Manchester, Newcastle, and Glasgow. Reading, and its biscuit-baking industry, and Norwich, with its mustard manufactory, are our best. Our district is composed mainly of residents and agriculturists; the former do not require telephones, and the latter, I much fear, cannot afford to pay for them. But we have, I consider, a mine of wealth within our reach if it is only developed. The multitude of City and business men who reside within a radius of 25 and 30 miles of London would—many of them—be thankful to be able to converse with their offices and places of business, and would pay handsomely for the convenience. In addition to this we have applications from towns within a moderate distance of London, who call loudly for communication. Chatham has applied, as also Windsor, Reading, Luton, Cambridge, and several others. We have urged this matter on the consideration of the parent company, the United, but up to the present no satatisfactory terms for the entry of trunk lines on to their system have been suggested. I trust, however, that the time will come, and that with no material delay, when we shall be enabled to carry out some scheme, which will, I am sure, prove of material benefit to both companies. As regards finance, we are certainly in smoother water than when I last saw you. I told you that we had a controversy with the representatives of the late Mr. Kendal as to 13,567 ordinary shares in the Company, which he had agreed to allot to the applicants for a like number of preference shares, the balance of our unissued capital. We were some time before we came to terms with these gentlemen. Ultimately, however, we consented, acting under the strong recommendation of our legal adviser, to accept a compromise of 10,000 ordinary shares in full, and as soon as we got possession of them on the 23rd November they were offered to our shareholders and renters as a bonus on their applying for a similar number of preference shares. There were applications for about 15,000 shares, which was considered to be a satisfactory result. On these shares 30s. each has been called up, the last call of 10s. being due 4th May, and the entire has been paid, with one trifling exception. The greater part of our expenditure, as you are aware, is on capital account, and as you will note from the figures in our report there is a debit of £5,632. 9s. 11d. against capital. In order to square this up we have decided to call another 10s. per share, payable 2nd August, on all our issued preferences, which, being 16,433, will yield us £8,216. 10s. There still remain unissued 3,567 preference shares. We are prepared to receive applications for them, with £2 paid, and are prepared to pay a 6 per cent. preference dividend on them on the terms of our prospectus, carrying interest from the commencement of our financial year, namely, 1st May last. We have, however, no bonus ordinary shares to allot with these. We paid an interim dividend of 6 per cent. per annum on our preferences on the 1st October last, and warrants for a second half-yearly dividend at the same rate will be posted this evening. These amounts, as you will see from the figures presented to you, have been fairly earned. I am sorry that your Directors cannot recommend any payment on account of the ordinary shares, as they at one time hoped to have been able to do. The task imposed on us, namely, to pay a dividend on £300,000 of paper shares is a very onerous one. Were we only to pay 1 per cent. in addition to the 6 per cent. on our preferences, which is a first charge on our net revenue, it would amount altogether to nearly 20 per cent. on our working capital of £22,000. This is a serious undertaking, and it must of necessity be a very good paying concern that can do it. But I, for one, do not despair, and trust that we shall at the end of another year, if no untoward accident again happens, be able to give a good account of ourselves. You may depend on the efforts of those on this side of the table being directed to effect this desirable end.

Mr. T. F. CAMPBELL seconded the motion.

A SHAREHOLDER said he thought that the accounts were not nearly so satisfactory as those for the previous year. The expenses in the last year's balance-sheet, with a revenue of £7,800, were £1,200, and this year, on a revenue of £11,400, the ordinary expenses had gone up to £3,460. He also desired to know how it was that the Post Office royalties had trebled, amounting to over £3,000 in the present balance. After allowing for the amount set aside for the snowstorm the accounts did not come out nearly so favourably. With an increase of nearly £4,000 in the revenue there had been only a net increase of £400, so that the prospect of a dividend on the ordinary shares looked very doubtful. He understood the Chairman at the last meeting to state that a dividend was in sight for the ordinary shareholders, and it was also in print that 1½ per cent. on the ordinary shares was carried forward then. He thought that the state of the Company's position ought to have been brought before the shareholders by circular, for during the whole of the year which had elapsed since their last meeting the ordinary shares had been changing in the belief that a dividend was to be soon paid on them. As late as a fortnight before the issue of the report he was told by a stockbroker that there was to be a dividend this year on the ordinary shares. The shares had been changing hands at 5s. to 6s., making the total market value of those shares between £70,000 and £80,000. With the increase in the preference shares it seemed to him that the ordinary shares are being put out of court altogether.

The CHAIRMAN stated that the trunk wire between London and Brighton was the property of the Post Office and the United Company, and the South of England Company paid a rental for it. All the trunk lines between Norwich and Yarmouth, and so on, belonged to this Company; but when they came into London the case was different. As soon as ever they could make a line to pay, they would run such a line. They got their agreements signed before they ran the line. Referring to the shareholder who had first addressed them, he said that the Directors could not be held responsible for what that gentleman had been told by stockbrokers as to the value of the ordinary shares, respecting which the Board had given no indication. Although a certain amount had been carried forward at the last meeting, there were all the expenses to come off. The snowstorm had caused them a very large outlay. They would have been able this year to have paid 1 per cent. on the ordinary shares but for the snowstorm, and he thought that 1 per cent. on £300,000 would be an uncommonly good dividend. In answer to another shareholder the Chairman stated that the claim (referred to at the foot of the balance-sheet) for £633 for royalty on surplus instruments was a matter of account between the United Company and the Company.

Mr. QUILTER, M.P., said he was quite sure as a Director of the United Company, who were very large shareholders in this Company, that nothing but what was right and fair would be required by the parent company. He certainly agreed with one of the shareholders who had already spoken, that the result of the past year's working by the Company had been very unsatisfactory. He might be wrong, but he regarded the field possessed by the Company as one of the best for telephonic enterprise in England. He would be more than disappointed if on the next occasion there was not quite a different balance-sheet. It was impossible to hold Directors responsible in connection with any purchase of shares, but he did feel that a great deal was to be said in favour of half-yearly meetings—a suggestion which he would be quite ready to support if the hon. shareholder who had raised the point would bring the matter forward by way of a substantive resolution.

The CHAIRMAN said he could not agree with Mr. Quilter that the Company had a very good district, which, as a matter of fact, was rather barren. The Directors had worked as hard as they could to promote the welfare of the Company, and they had great hopes of doing better; but they had been seriously affected by the snowstorm.

Dr. ELLIS, of Eastbourne, referred to the prominent part which he had taken to induce the Town Council there to allow the use of overhead wires. The progress of the enterprise at Eastbourne had been rapid, and he thought that within the last twelve months the Company had done all that could reasonably have been expected from it. Owing to the executors of the late Chairman holding the ordinary shares for some time there was a difficulty in raising the additional capital required, and no doubt 12 or 18 months ago they were not in a position to raise sufficient capital to carry out the necessary works. As soon, however, as the present Board obtained capital, the results were at once seen. Judging from what had been done at Eastbourne, he thought that the Directors had displayed considerable energy. The shareholders ought not to forget the adverse effect on the Company of the snowstorm. At no very distant period the Government had the option of taking the lines, and therefore it was to the interest of the Directors and the shareholders that the system should be developed on the largest possible scale in the shortest possible time. He suggested that the Directors might, by means of lectures, at the cost of a few pounds, endeavour to make the uses of the telephone more generally known.

The CHAIRMAN said that the Directors would consider the subject of half-yearly meetings, with every desire to carry out what was wished; but there was some difficulty in connection with the accounts.

At the instance of Mr. WILLIAM ROE a resolution was passed expressing the opinion of the meeting in favour of half-yearly meetings, at which the Chairman should make a statement as to the progress of the Company, but at which a balance-sheet need not be presented.

The CHAIRMAN, in reply to a question, said that there would be no difficulty in informing the shareholders at the meetings of the number of subscribers at each of the towns as compared with the number at the time of the previous meeting.

Mr. HENRY ROBERTS then proposed, and Mr. W. A. MACGREGOR seconded, the resolution to the effect that the Directors should receive the sum of £700 for their services during the twelve months ended 30th April, 1887.

The CHAIRMAN, in explanation, said that immediately after the last meeting the Directors appointed him Managing Director at a remuneration of £500. That resolution was handed to the United Company, who referred it to Mr. Brand, who decided—and they had that gentleman's letter to that effect—that the £500 should be passed; but it was to appear in the way the mover of the resolution had put it. He (the speaker) gave his whole time to the affairs of the Company.

A SHAREHOLDER said that the shareholders were asked to augment their expenses by £500 a year in a very bad year.

The CHAIRMAN said that that was not the case. The amount mentioned was in the accounts. Part was in the item of general management,

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salaries, &c., and part had gone to construction account, because half his time was spent in the country.

After some further discussion,

Mr. QUILTER stated that he knew nothing about the approval of the United Company having been given in regard to the question under discussion.

Mr. ROE moved and Mr. FITZGERALD seconded a resolution adjourning the meeting for a fortnight for the purpose of completing the business, which was passed.

On the motion of Mr. QUILTER, a vote of thanks was passed to the Chairman, and the meeting then separated.

United Telephone Company (Limited).

Report of the Directors for the year ending 30th April, to be presented to the shareholders at the seventh annual ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, E.C., on Tuesday, July 5th, 1887, at two o'clock :—

A reference to the capital account will show that up to the 30th April, 1887, the sum of £228,180. 12s. 2d. had been expended upon the works in connection with the Metropolitan District and instruments on royalty in the Metropolitan District and subsidiary companies, being £41,513. 18s. 2d. more than the outlay shown in the last balance-sheet. The revenue accounts, exclusive of Metropolitan District royalties, show that the receipts of the Company from all sources properly attributable to the year have been £130,704. 7s. 5d., as against £122,283. 15s. 1d. in the preceding year, or an increase of £8,420. 12s. 4d., and the expenditure (including snow storm expenses, &c., £15,777. 0s. 8d.), has been £66,954. 11s. 8d,, as against £54,681. 6s. 1d., or an increase of £12,273. 5s. 7d. The working expenses of the Metropolitan District for the year have been £30,483. 14s. 2d., as against £32,548. 4s. 8d. for the preceding year, or a decrease of £2,064. 10s. 6d. The balance of net revenue account is £62,235. 17s. 3d., of which amount the sum of £22 377. 15s. has been absorbed by the payment of an interim dividend at the rate of 10 per cent. per annum for the first half year ended 31st October, 1886, and the Directors recommend a further dividend of 8s. per fully paid £5 share (part paid shares receiving in proportion) for the second half year ended 30th April, 1887, amounting to £35,804. 8s., making a total dividend of 13 per cent. for the year, leaving a balance of £4,053. 14s. 3d. to be carried forward. A sum of £4,203. 9s. 10d., representing profits derived from exceptional sources, &c., has been carried direct to the reserve fund, in addition to the amount set aside for depreciation on instruments. Mr. James Brand, Mr. James Staats Forbes, and Mr. Joseph B. Morgan retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Messrs. Quilter, Welton and Co., and Messrs. Price, Waterhouse and Co., also retire.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 29.		BUSINESS DONE WEEK ENDING JUNE 29. Highest.	Lowest.
Anglo-American	35,	36	35	—
Do. Preferred	57,	58	57⅞	57½
Do. Deferred	13½,	14½	13⅞	13⅝
Brazilian Submarine	11,	11½	11 5-16	—
Cuba	12,	12½	—	—
Do. Preference	18,	19	—	—
Direct Spanish	2⅞,	3	—	—
Do. Preference	7½,	8½	—	—
Direct United States Cable	8⅜,	8⅝	8¼	8⅛
Eastern Telegraph	10¾,	11	10 15-16	10⅝
Do. 6 per Cent. Preference	14,	14½	14½	14
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	11⅜,	11⅝	11⅝	1·⅜
German Union	10½,	11	—	—
Globe Telegraph and Trust	5⅜,	5⅝	5 7-16	5½
Do. Preference	13,	13½	13½	13 1-16
Great Northern	13¾,	14	—	—
Indo-European	34,	35	—	—
Reuter's	7⅜,	8½	—	—
Submarine	180,	190	—	—
West India and Panama	⅝,	¾	⅝	—
Do. 1st Preference	8½,	9	—	—
Western Brazilian	8⅜,	8⅝	8 5-16	8⅛
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	104,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	—	—	xd.
Oriental	⅜,	⅝	—	—	
United Telephone	12⅛,	13⅛	—	—	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅛,	3⅛	2 11-16	2⅝	
Do. (fully paid)	4,	4½	4	—	
Swan	1⅛,	1½	—	—	
Maxim Weston	3-16,	5-16	—	—	

MISCELLANEOUS.

Telegraph Construction	36,	37	37	36	
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23½	

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 24th inst. amounted to £4,147.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due on the 30th inst. on the debentures of this company will be paid by Messrs. Barclay, Bevan and Co. The coupons must be left three clear days for examination. The directors have declared an interim dividend of 4s. per share, free of income-tax, in respect of the first half of 1887, payable 15th July, 1887.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 24th inst. amounted to £3,429, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE ELECTRIC APPARATUS COMPANY, Limited.
Head Office and Warehouse: 50, Bow Lane, Cheapside, E.C.
Depots: 4, Charing Cross, S.W., and 65, Faulkner St., Manchester.
Works: Arnold Road, Bow, E.
Electric Light Fittings, Edison-Swan Lamps, Schuckert's Ammeters, Voltmeters and Speedometers.
Specially Low Quotations for Electric Light Cables.
BELLS, INDICATORS, BATTERIES, WIRES, &c.
MEDICAL APPLIANCES.
SHIPPERS AND THE TRADE SPECIALLY STUDIED.
NO CONNECTION whatever with any Firm trading under a SIMILAR TITLE

RICHARD JOHNSON & NEPHEW,
MANCHESTER,
TELEGRAPH AND TELEPHONE LINE WIRE,
And Sole Manufacturers in Great Britain of the
PATENT STEEL BARB FENCING.
London Office: 8, GREAT WINCHESTER ST., E.C.

CARBONS.
SOLID 11mm. RODS 1½d. per foot, nett.
OTHER SIZES AND PLATES EQUALLY CHEAP.
BARNSLEY CARBON COMPANY,
BARNSLEY.

STANHOPE
PATENT ELECTRIC TELEPHONES.
NO CARBON USED.
No Microphone to get out of order.
SUITABLE FOR
LONG OR SHORT LINES.
RAILWAYS AND PUBLIC WORKS.
EXCHANGES AND HOTELS.
WAREHOUSES AND FACTORIES.
LOUD AND CLEAR. ESTIMATES FREE.
STANHOPE COMPANY, Limited,
20, BUCKLERSBURY, LONDON, E.C.

Hedges' Patent Switches.
All Sizes, from 1 to 300 Amperes.
Mounted on Polished Wood or Enamelled Slate Bases.

The Cheapest and Best Switches in the market.
Good Rubbing Contact.
THE GLOBE ELECTRICAL & ENGINEERING CO.,
Offices and Show Rooms: 7, CARTERET STREET, WESTMINSTER, S.W.

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NOTES.

EDISON.—Mr. Edison, it is said, is about to construct a great experimental laboratory at his home in Orange, New Jersey.

TENDERS FOR LAYING UNDERGROUND WIRES.—In our advertising columns particulars will be found as to the laying of underground wires required by the Hornsey Local Board.

THE PORTRUSH ELECTRIC TRAMWAY. — The Portrush electric tramway has now been extended from Bushmills to the Giant's Causeway, and the extension has been in use since the 1st inst.

TELEGRAMS BY TELEPHONE.—The delivery of telegrams by telephone has become very popular in Belgium. The average number of telegrams passing through the telephone exchanges daily now exceeds 1,200.

THE INTERNATIONAL CONFERENCE ON SUBMARINE CABLES. The International Conference on the protection of submarine cables, which suspended its sittings in December last, meets again this week in Paris, under the presidency of M. Flourens.

ROYAL SOCIETY OF VICTORIA.—We have received copies of the 22nd and 23rd volumes of the *Transactions* of the above society. These volumes contain a paper on "Systems of Electric Lighting," by Mr. J. Booth, and one on "Lightning Conductors," by Prof. W. C. Kernot.

THE ELECTRIC TELEGRAPH JUBILEE DINNER.—The meeting of the committee, which in our last issue we announced to be held on Tuesday, July 5th, should have referred to the *sub*-committee. The next meeting of the general committee will be held on Tuesday next, July 12th.

SPAIN.—The Madrid paper, *El Imparcial*, states that active preparations are being made for the installation of the electric light at Pontevedra in the province of Galicia.—It is reported that Madrid is to be added to the list of towns in which the electric lighting of theatres has been made compulsory.

IRON TELEGRAPH POLES.—A local paper states that Messrs. Bayliss, Jones and Bayliss, of Wolverhampton, have secured an order to supply a colonial market with 50,000 iron telegraph poles. This order is probably the one referred to in the specification published in this journal on the 24th ult.

TOLEDO, SPAIN.—The municipal authorities have decided upon adopting the electric light for public lighting, and a notification dated Toledo, 30th June, appears in the Spanish papers inviting proposals to be sent in within a period of 45 days from that date. The conditions can be seen at the Secretaria Municipal do Toledo, and in the leading towns of the province.

RAILWAY CARRIAGE LIGHTING IN GERMANY.—A train of six carriages on the Main-Neckar Railway, running between Darmstadt and Heidelberg, has been lit during the past month with electric light. Each carriage is supplied with two secondary batteries containing each eight Khotinsky cells. One of these batteries is in use while the other is being recharged by a dynamo placed in the guard's van.

THE OERLIKON DYNAMO.—In the Liverpool Exhibition (Machinery Court). Mr. B. H. Thwaite, C.E., has just fixed an Oerlikon dynamo. This type, patented by Mr. C. E. L. Brown, has given wonderfully high efficiency results, stated to be 98 per cent. electrical and 96 per cent. commercial. In this dynamo there is no sparking at the brushes. The machine is described as a perfect model of mechanical engineering.

TENDERS WANTED FOR PUBLIC LIGHTING.—In our advertising columns particulars will be found as to the lighting of the town of Malton, about which the local authorities would like to hear from some of the electrical engineers.—Tenders are also asked for lighting 120 public lamps in the district of Great Ilford (Essex) "with gas, paraffin oil, or electric light." Further information may be obtained from Mr. A. Sherman, clerk to inspectors, 1, Oakfield-road, Ilford.

"JOURNAL OF THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS."—The sixty-seventh issue of this journal, which has just been issued, contains the papers by Profs. Ayrton and Perry on "Self and Mutual Induction," and the paper by Mr. W. E. Sumpner on the same subject; also the paper on "Underground Telegraphs," by Mr. C. T. Fleetwood, and on "Driving Dynamos by Very Short Belts," by Profs. Ayrton and Perry, together with the several discussions.

THE LIGHTING OF THE CITY OF LONDON.—At the last meeting of the Commissioners of Sewers the clerk submitted a notice of Messrs. Bircham and Co., on behalf of the South Metropolitan Electric Supply Company, that application is intended to be made under the Electric Lighting Act, 1882, in the ensuing session, for a Provisional Order for power to supply electricity for lighting and other purposes in certain streets and places within the City. It was referred to the Streets Committee.

THE FINSBURY TECHNICAL COLLEGE.—The students' *conversazione* at the Finsbury College on Friday next promises to be a more than usually interesting affair. In addition to the usual display of scientific apparatus, &c., there will be a lecture by Prof. Ayrton on "Church Bells," illustrated by working models, and one by Prof. Neldola on "Spectrum Analysis." An illuminated fountain will play in the court yard, and the concert to be given in one of the rooms will be transmitted telephonically to another part of the building.

THE WEST METROPOLITAN TRAMWAYS.—The Bill promoted by the West Metropolitan Tramways Company to authorise the use of electrical or other mechanical power on their existing tramways came again before a Select Committee of the House of Commons on the 12th inst. The Metropolitan Board of Works appeared as opponents, on the ground that it was *ultra vires* for the provisional order which the Bill confirms to be issued without the consent and approval of the local authorities. The Committee, however, passed the Bill.

BOURNEMOUTH.—On Thursday evening a lecture on "Lighting, Past and Present," was delivered before the members of the Bournemouth Society of National Science by Mr. Octavius Curtis. The latter part of the subject was illustrated by a number of arc lamps of various types which had been lent by Messrs. Mortimer, Shepherd and Co., a firm which, as our readers are aware, has been running an electric station at Bournemouth during the last few months. We were pleased also to learn that there is a probability of the installation assuming a permanent character.

WHERE WAS IT?—From the top of Titterstone Clee Hill, in Shropshire, on the night of the Jubilee celebrations, about 100 bonfires were visible. Amongst these a brilliant white glare, in the direction N.W. by N., was universally believed to be due to the electric light, but it has not yet been discovered from what locality it proceeded. A line drawn on the Ordnance Map in the direction indicated passes over the towns of Shrewsbury, Chester, and Liverpool, distant respectively as the crow flies 20, 55, and 67 miles. It appears that neither at Chester nor at Shrewsbury were any electric lights displayed on the 26th ult. It would be interesting to know whether a light at Liverpool was actually visible from this distance.

THE ELECTRIC LAUNCH "THE COUNTESS."—It is stated that Elieson's electric launch will go down to Spithead for

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the Naval Review on the 23rd inst. Our readers will remember that this boat carries on board an engine to be used for recharging the accumulators. On the authority of a paragraph in a daily journal we now learn that this engine "derives its power from the force accumulated by the vessel's passage through the water." The engine charges the accumulators, the accumulators drive the motor, the motor propels the vessel, and the vessel "accumulates" the power which works the engine. Mr. Elieson has doubtless been grossly libelled by the reporter in being made to appear as a perpetual motion man.

CENTRAL STATION LIGHTING IN PARIS.—The opening of the Montmartre central station will very shortly be followed by a second in the neighbourhood of the Pantheon, where a 2,000-light plant is now being erected by the Société d'Oerlikon.—M. Philippart has applied for the authorisation of a scheme for lighting all the public buildings in Paris by means of accumulators to be charged from a central station.—A similar scheme (and one we should say with as little chance of success) has been set on foot by the Société pour la Transmission Electrique de la Force, which proposes to light all the theatres in Paris from a single station.—The new Opera Comique will be lit by the Edison Company.

PRICE LIST.—Mr. G. Sharples, of Preston, sends us a copy of his illustrated descriptive catalogue and price list, which contains a remarkably extensive list of physical and chemical apparatus of all kinds. Mr. Sharples is well known as having had the good fortune to acquire a large stock of royalty-paid Gower-Bell telephones at the time when the instruments were in the market. The list before us contains also a good deal of useful information for amateurs and others on such subjects as the proper way of using and maintaining batteries of various types, methods of connecting electric bells, annunciators, and telephones, and the fixing of lightning conductors; also information concerning the Science and Art Department and grants in aid of the purchase of apparatus for science schools, &c.

CONVERSAZIONE AT THE SCHOOL OF TELEGRAPHY, PRINCE'S STREET, W.—On the evening of Friday, July 1st, a *conversazione* was held at the School of Telegraphy and Electrical Engineering, in Prince's-street, Hanover-square. The guests were received by Mr. Wm. Lant Carpenter and Mr. Leon Drugman, and found much to interest them in the display of electrical and physical apparatus, the lantern "lecturettes," by Mr. A. D. Wilkinson and Mr. E. C. Rimington, and the very enjoyable musical programme which had been provided. A loan collection of apparatus was also on view, to which the principal contributors were Messrs. Nalder Brothers and Co., Messrs. Immisch and Co., and Messrs. F. E. Becker and Co. Amongst those present were Prof. Silvanus Thompson, D.Sc.; Mr. Swan, F.C.S.; Dr. Fleming, Mr. Desmond FitzGerald, Mr. Sidney Sharp, Mr. W. B. Esson, Mr. Immisch, and many old pupils of the School.

THE ELECTRIC LIGHTING BILL.—It is stated that Mr. Hugh Watt intends shortly to give notice in the House of Commons of the following resolution:—"That the Electric Lighting Amendment Bill introduced by Lord Thurlow in the House of Lords having been deprived of its most important provision by the decision of the Committee of that House, and thus rendered useless for the purpose for which it was intended, no measure short of a repeal of the Electric Lighting Act (1882), and the substitution therefor of legislation rendering it possible to supply electric light to the public with a fair prospect of remunerative returns, will be of any benefit to the electric lighting industry, and as that Bill has to a very large extent destroyed the growth of the industry in this country and driven the export trade into American hands, it is desirable that the aforesaid Act be forthwith repealed, and those engaged in this new industry (which now employs nearly £50,000,000 of capital, and over 50,000 workmen in America) be freed from the fetters of legislation, which have proved of so disastrous a character."

BATH.—During the Jubilee celebration at Bath the market place was illuminated by Mr. Massingham with a Thomson-Houston 30 arc light plant; and on Monday last a lecture on electric lighting was delivered in the theatre by Mr. Wharton, the mayor occupying the chair. Considerable interest was manifested by the audience, and at the close of the lecture Mr. Wharton replied to a number of questions. We regret to learn that a misunderstanding of some kind has subsequently arisen between Mr. Massingham and the Corporation, and the lights in the market place were ordered to be removed several days earlier than had been originally intended. The local journals publish a correspondence between the parties concerned, but the origin of the squabble is not made very clear. In erecting the lamps, Mr. Massingham had been allowed to use the fire escape to reach the front of the Guildhall, but the officials thought proper to refuse this facility for their removal. Whatever may be the actual merits of the quarrel, an incident of this kind is unhappily sufficient to prove the narrow-minded provincialism of the authorities of the ancient city of Bath.

BERLIN.—The Berlin correspondent of *Industries* states that some large and comprehensive schemes for the extension of the existing central electric light stations, and the establishment of two new ones, have fallen through, the reason being a disagreement between the Town Council and the Edison Company. Hitherto the fitting up of the electric light on the consumers' premises has been carried out by the Edison Company; but the Town Council wanted to secure to consumers the right of having their installations fitted up by third parties, the electric light company to supervise and pass the work, for which they were to be paid at the rate of 10 per cent. on the cost, whilst the supervision for work done for the municipality would only be paid at 5 per cent. on the cost. To these innovations the Edison Company would not agree, and the negotiations were thus brought to a close. The central stations under the management of the town will now be increased so as to furnish current for 40,000 glow lamps. Experience has shown that out of the total number of lamps fixed only two-thirds are ever lighted simultaneously, and therefore the enlarged stations will be able to serve a district containing 60,000 lamps.

THE CAUSES OF DEATH BY ELECTRICITY.—The *Lancet* remarks that the observation of M. D'Arsonval that dynamic discharges and alternating currents do not (like static discharges) produce serious organic disruption of the lining tissues is not a new discovery. The special disruptive and fatal effect of the statical discharge has long been known in this country, and was most fully brought out in Dr. Richardson's experiments on death by electric shock, conducted in the Royal Polytechnic Institution in 1869. In those researches sheep and other animals were killed by the statical discharge, and the cause of death was shown to be due to the sudden expansion of gaseous parts of the blood and tissues, by which organic lesions of the most extensive kind were induced. In one of this series of experiments the skull of a dead animal was fractured by the statical discharge, and arborescent markings of external veins, distortion of large veins, rupture of the heart, ecchymosis, rupture of the stomach, and decomposition of the blood itself, from the same kind of discharge, were phenomena

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traced to disruption from gaseous expansion. At the same time the statical discharge does not always kill. It may simply stun, or cause a temporary anæsthesia, or produce a state resembling catalepsy, followed by recovery.

THE GAS INSTITUTE.—The annual general meeting of the Gas Institute was held last week at Glasgow. The President (Mr. William Foulis, M.I.C.E.) made the following sensible remarks upon the relations between electricity and gas:—"Notwithstanding the continued depression of trade throughout the country gas manufacture continues to prosper. The quantity produced is steadily increasing, greatly due, no doubt, to the varied uses to which gas is being applied. The most timid shareholder no longer fears electricity as a possible extinguisher of gas, although this system of lighting is also making progress; and with so many minds engaged in its development it must progress both in efficiency and economy. In both of these respects gas lighting is still well in advance. Our duty is not in any way to impede the development of electric lighting, but rather to render it every assistance, while at the same time we strive to cheapen and improve the mode of lighting in which we are more immediately interested. We have to thank the introduction of electric lighting for much of the progress that has been made in recent years in improving the lighting power of gas, in creating a demand for more brilliant illumination, and in stimulating invention to supply the demand."

TRANSFORMER EFFICIENCIES.—In another column will be found a note by Captain Cardew (which we reprint from *Industries*) on the efficiency of the Gaulard-Gibbs transformer. It is satisfactory to find that these tests are in agreement with earlier measurements in assigning an efficiency of considerably over 90 per cent. Captain Cardew's note is interesting also as affording a confirmation of Mr. Kapp's recent theoretical prevision that the limiting value of the sum of the angles expressing the lag of the primary current over impressed E.M.F., and the lag of magnetisation over the primary current is always 90°, and this value is approached asymptotically as the efficiency increases. In the series of experiments in which the periodic time (or number of revolutions) was allowed to vary, seeing that the efficiency of a transformer is a function involving this quantity, it is rather a pity that the speed of the machine is not given in the tables. It is obvious that the efficiency of a transformer would increase continuously with the rate of alternations if it were not for the simultaneous increase of Foucault currents in the core; hence every transformer has a particular value of the periodic time for which its efficiency is highest, and that type of transformer in which the Foucault current loss is least will naturally have its highest efficiency at a relatively higher output.

ERRORS IN TRANSMISSION.—Errors in the transmission of telegrams, says the *Evening Standard*, very frequently occur, but it rarely happens that the consequences of such errors are sufficiently serious to induce the receivers of the incorrectly transmitted message to bring an action for damages for shock to the system. This, however, has been the case in America, the plaintiff being a Mr. Laviolette, a New York business man, who has sued the Western Union Telegraph Company under the following circumstances:—He resided in Astoria, and some time back started for Syracuse to see his son, a pupil at a boarding school near that place, intending to accompany him home. On the arrival of the train at a certain station a Western Union telegram was handed to Mr. Laviolette, which read, "Lewis (the son) is dead." It was signed by his wife, and, greatly shocked at the news, the father continued his journey to Syracuse, where he expected to find the boy's corpse; but on reaching his destination he learned that his son had left by rail on the previous day. He could learn no tidings of him on the route back, and concluded that he must have been killed in some railway accident. Reaching his home in Astoria, he was agreeably surprised, however, to find the boy with his mother, alive and well. It turned out that the message sent by his wife was—"Lewis is home," and that all his anxiety, suspense, and suffering were due to an error in transmission. Under the circumstances, Mr. Laviolette determined to sue the telegraph company, claiming $2,000 for shock to his system, loss of time, and expense occasioned by the delivery of an untrue message; the hearing of the case is to come on shortly.

COST OF ELECTRIC LIGHTING AT BREMEN.—The *Deutsche Bauztag* says that during the progress of the dredging operations which have been going on day and night in the harbour at Bremen it was decided to replace the lanterns and petroleum flare-lights by the electric light, and the contract was given to Messrs. Schückert, of Nürnberg, their tender being the lowest. They were able to reduce the cost of the installation by utilising the surplus power of two steam boilers at the chief pumping station, and by making use of a 25 horse-power reserve engine, already in position, to drive the dynamo, the arrangements being such that the engine could also be made to work a centrifugal pump if required. The engine was driven at 180 revolutions per minute, and the dynamo of the Schückert type constructed to give a current of 16 amperes with 840 revolutions per minute, but 14 or 15 amperes only were utilised in the present case. The light was obtained from 12 arc lamps, each of about 3,000 candle-power, enclosed in clear glass globes of 45cm. in diameter, furnished with overhead reflectors a metre in diameter, and attached to masts 20 metres high. The circuit wires were suspended on ordinary telegraph poles six to seven metres high by means of porcelain insulators. The total cost amounts to 3·62d per lamp-hour. The electric light has been found much more satisfactory than the petroleum lights, especially in wet or stormy weather, when the latter, besides being frequently extinguished, consumed about twice as much petroleum as in fine weather. Experiments are now being carried out to determine how many of the petroleum lights would be required to produce an illumination equivalent to that of one of the arc lamps.

DR. O. FRÖLICH ON DYNAMOS.—Dr. Frölich, writing in the *Electrotechnische Zeitschrift*, gives some measurements upon the increase in the impedance of the armature of a Siemens D_2 machine with increasing velocity of rotation. The armature resistance measured 0·3 ohm. When mounted in a wooden frame, and run at 1,100 revolutions, the impedance was 0·911 ohm; while, when in position in the machine, the impedance amounted to no less than 3·62 ohms, the difference being, of course, due to the increased magnetisation of the core. Dr. Frölich makes the remark that the coefficient at a given velocity is independent of the position of the brushes, and also of the magnetic intensity of the armature field [current in armature]. This, however, merely shows that the machine was working on the horizontal part of the characteristic. He adds that in the machine used as a motor there is some variation which requires further investigation—a conclusion at which several other investigators have arrived. The chief discrepancy is undoubtedly due to the fact, pointed out by Mr. Mordey, of the different relations of the Foucault currents in the two cases; but this does not seem to cover the whole of the ground. Dr. Frölich, in conclusion, advances the opinion that the characteristic curve of a machine is not the

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end of the theoretical discussion, but rather the beginning, and gives a solution of only a few points required, and by no means an insight into the behaviour of the machine; and to the "knights of the characteristic" he propounds the following proposition:—Given, for a simple shunt-wound machine in which the armature exerts considerable reflex action, a series of experimental observations with different external resistances and velocities; required, the electrical qualities of the machine demonstrated in such a manner as to give a sufficiently accurate solution without special difficulty, and at the same time an insight into its internal economy.

THREEPENNY TELEGRAMS.—Mr. E. Cox-Walker, of Darlington, writes to the *Northern Echo* as follows:—"The idea of the above, when we have only just entered upon the 'sixpenny' state, may seem somewhat premature—and perhaps it is—but only slightly so, and then only so long as it would take the Postal Telegraph Department to prepare for it. The wonderful way in which the reduction to sixpence has increased the use of the telegraph, and rendered its further development so desirable to all commercial men in particular, is my reason for indicating what it must shortly come to, and the way in which this further reduction in the price would influence and enormously extend the use of the telegraph may be gathered from a consideration of the present cost of a letter with its penny stamp, paper, and envelope, and the time occupied in writing. There cannot be a doubt in any one's mind as to the enormous increase that would take place, and the benefits which would arise therefrom to the commercial world, which is really the great user of this mode of communication. The cost of transmitting messages will, of course, be greatly reduced, as regards each message, by the full use made of all the instruments and wires. Then the capacity of the carrying power of the wires is being greatly increased by the substitution of copper for iron wires by the Telegraph Department; and the speed at which signals and words can now be transmitted has been wonderfully increased during the last year or two—news being now sent at the rate of 450 words per minute between London and Ireland and elsewhere. There is also an immense increase in the number of the wires between town and town during the last few years; and the telephone companies have made us acquainted with the fact that messages are constantly passing between their subscribers in and about London at an average cost of about a penny. Everything, therefore, seems to point out to us that the Postal Telegraph Department might, at any time when they are prepared to do the enormously-increased work, reduce the charge to threepence for twelve words, to the great advantage of the country at large."

THE POSTAL TELEGRAPH SERVICE.—In the House of Commons on Friday last Mr. Raikes, in answer to Mr. De Lisle, said:—"The accounts for the last financial year have not yet been closed, and I am therefore unable to furnish any more definite information as to the deficiency in the telegraph revenue than I did on the 6th ult., when the votes for the Post Office were under discussion in this House. I then stated that there was a permanent charge of £326,000 for interest on capital, and that the actual deficit on the working of the telegraph system was estimated at £223,000, making a total deficit for the year of about £550,000. The estimate of a loss of £223,000 on the working of the system has reference to the whole of the telegraphic business of the Department, including inland telegrams, foreign telegrams, press telegrams, the rentals of private wires, and various other branches of the business. So soon after the introduction of the reduced rate I do not see my way to advise Her Majesty's Government to make any further alteration in the charge for telegrams; and although, for some reasons, it would be better, both for the public and the Department, that the registration of abbreviated addresses should be abolished, I think it would be difficult to withdraw the privilege of registration at present. I will, however, cause the system to be carefully watched, and will not lose sight of the suggestion made by the hon. member. I regret that it is not in my power to state what is the present proportion of stock and betting messages, but a return is now in course of preparation, which I hope to be able to publish before the end of the year, giving the desired information for a week just prior to the introduction of the new rate and for a corresponding week of last year. I do not see how arrangements could be made to deliver telegrams free at the houses of persons who live in places outside the free delivery of any telegraph office without increasing the loss which is already incurred on the telegraph business of the country."

THE INSTITUTION OF CIVIL ENGINEERS.—In the Court of Queen's Bench last week a case came before the Lord Chief Justice and Mr. Justice Field, in which the question involved was whether the Institution of Civil Engineers was liable to assessment under the Customs and Inland Revenue Act of 1885, which provided that corporate bodies should pay 5 per cent. on the annual value, income, or profits, of their property, in lieu of probate, legacy, and succession duties, it being contended on behalf of the Institution that it came within the exemption contained in the Act applying to property legally appropriated or applied for any purpose connected with any religious persuasion, or for any charitable purpose, or for the promotion of education, literature, science, or the fine arts. The Solicitor-General (for the Inland Revenue authorities) argued that this was not an association for the promotion of education, literature, science, or the fine arts within the meaning of the Act. It was an association of gentlemen, who for their own purposes and advantages in their profession came together and provided themselves with appliances which were very necessary for the objects they had in view. Mr. Charles submitted that the institution was covered by the exemption, as it was devoted to education with regard to the promotion of mechanical science. Last year there were 900 students connected with the institution. The Lord Chief Justice was of opinion that the institution was liable to pay the duty, on the ground that the exemption applied to associations generally devoted to education, literature, science, and the fine arts, and this association was only for the promotion of a particular branch of knowledge, for the purpose of increasing the intelligence and cultivation of a particular profession. If this institution were exempted it would be difficult to know where to stop in regard to the exemption of teaching institutions. Besides, the point was concluded by authority, it having already been held that this very institution was liable to pay poor rates, although there was a slight distinction, inasmuch as the Act in that case provided that associations to be exempt should be exclusively devoted to charitable or educational objects. Mr. Justice Field concurred. Judgment for the Crown accordingly, with costs.

OPPOSITION TO THE ELECTRIC LIGHTING OF THEATRES IN PARIS.—The movement in favour of effecting the compulsory lighting of theatres by electricity is being energetically opposed by a portion of the Parisian press. The extraordinary and practically prohibitive regulations, which were drawn up by the Prefecture of Police before the catastrophe at the Opéra Comique, and which still remain in force, tend also to show that the opponents of electricity are able to exercise considerable influence in certain quarters and will not scruple to avail

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themselves of every weapon within their reach. Only upon such grounds does it seem possible to account for an article which has appeared in *La Liberté*, and has been reproduced in one of the financial journals. This article begins by pointing triumphantly to the action of the French insurance companies, who at present require an increased premium upon the introduction of the electric light, though we have little doubt that, eventually, the example of the English offices in this matter will be widely followed. The writer sapiently proceeds in the following strain :—"Electricity is not, after all, that which we call lighting, it is a universal property of matter. In introducing electricity into a place of public entertainment, we add one danger more, a special and frightful (*fondroyant*) danger, which has already made many victims. But this is not all ; in order to produce electricity—as we do not at present know how to bottle up natural electricity, atmospheric and terrestrial—we are driven to create the magnetic current, and to establish in the building powerful steam or gas engines whose presence gives rise to a double risk of fire or of explosion. Still further, the wires develop an intense heat which frequently sets fire to adjacent woodwork. This effect is above all produced when the consumption of current is less than the production. In theatres, the scintillation of the light rapidly becomes insupportable. We are, moreover, to be exposed to sudden extinctions, which would give rise to the greatest inconvenience, unless, indeed, we employ accumulators. But these latter offer such numerous chances of accident that even when they are purchased, people seldom dare to use them (!) as in the Hotel de Ville of Paris, for instance." We need waste no time in commenting upon this preposterous article, which in every sentence displays the grossest ignorance and the most reckless perversion of the truth.

THE ROYAL METEOROLOGICAL SOCIETY.—At a meeting of this society, held on June 15th, the following papers, amongst others, were read :—"Note on a Display of Globular Lightning at Ringstead Bay, Dorset, on August 17, 1876," by Mr. H. S. Eaton. Between four and five p.m. two ladies who were out on the cliff saw surrounding them on all sides, and extending from a few inches above the surface to two or three feet overhead, numerous globes of light, the size of billiard balls, which were moving independently and vertically up and down, sometimes within a few inches of the observers, but always eluding the grasp; now gliding slowly upwards 2ft. or 3ft., and as slowly falling again, resembling in their movements soap-bubbles floating in the air. The balls were all aglow, but not dazzling, with a soft superb iridescence, rich and warm of hue, and each of variable tints, their charming colours heightening the extreme beauty of the scene. The subdued magnificence of this fascinating spectacle is described as baffling description. Their numbers were continually fluctuating; at one time thousands of them enveloped the observers, and a few minutes afterwards the numbers would dwindle to perhaps as few as twenty, but soon they would be swarming again as numerous as ever. Not the slightest noise accompanied this display.—"Ball Lightning Seen during a Thunderstorm, on July 11th, 1874," by Dr. J.W. Tripe. During this thunderstorm the author saw a ball of fire, of a pale yellow colour, rise from behind some houses, at first slowly, apparently about as fast as a cricket ball thrown into the air, then rapidly increasing its rate of motion until it reached an elevation of about 30°, when it started off so rapidly as to form a continuous line of light, proceeding first east, then west, rising all the time. After describing several zigzags, it disappeared in a large black cloud to the west, from which flashes of lightning had come. In about three minutes another ball ascended, and in about five minutes afterwards a third, both behaving as the first, and disappearing in the same cloud.—"Appearance of Air Bubbles at Remenham, Berkshire, January, 1871," by the Rev. A. Bonney. Between eleven and twelve a.m. a group of air-bubbles, of the shape and apparent size of the coloured india-rubber balls that are carried about the streets, were seen to rise from the centre of a level space of snow within view of the house. The bubbles rose to a considerable height, and then began to move up and down within a limited area, and at equal distances from each other, some ascending, others descending. These lasted about two minutes, at the end of which they were borne away by a current of air towards the east, and disappeared. Another group rose from the same spot, to the same height, with precisely the same movements, and disappeared in the same direction, after the same manner.

THE JUBILEE OF THE TELEGRAPH.—At the Jubilee meeting of British electricians, held in New York on June 20, Mr. F. W. Jones, general manager of the United Lines Telegraph Company, in responding to the toast of "Our Profession," spoke as follows :—To me having been assigned the honour to acknowledge in behalf of the telegraph the toast so heartily dedicated to "Our Profession," I deem it incumbent on me as an American citizen to pay my respects, first of all, to the foremost object of this celebration, the golden anniversary of the reign of your gracious Sovereign, in whom "a thousand claims to reverence close, as mother, wife, and Queen," and in behalf of the American members of the telegraph I proffer our united congratulations to the illustrious electricians who have met here to night to pay loyal homage to their revered ruler ; and we cherish the hope that Victoria may long be spared to continue her fostering care over science and art, and to use her good offices in the furtherance of peace and goodwill between our respective countries, and may the stars and stripes, the banner of the brave and the free, ever lovingly entwine its folds with the folds of the union jack, which "has braved a thousand years the battle and the breeze." I come now to a more delicate part of my duty in responding to the toast proposed in honour of our profession. In doing this I cannot confine myself to any country, nor to any time. Science knows no political boundary. The whole world is ours, and telegraphers of every clime are brothers. The lines which stretch from San Francisco over continents and under seas to Japan, New Zealand, and South America include a "million miles of wire," connecting every community of civilised beings on the face of the earth, and endow our profession with a cosmopolitan character. We heartily join with you to-night in commemorating the grand achievements of William Fothergill Cooke and Charles Wheatstone in the year 1837, the very dawn of the electric telegraph. But for them I do not think we would have cable telegraphs to-day, and New York, to-night, would not have witnessed such a notable gathering of British electricians who have adopted this country for their field of labour and residence. In paying this highly-deserved tribute to the two illustrious men who were the first to put in operation a line of telegraph from Euston Station to Camden I do not wish to detract in the most remote degree from those great discoverers and inventors in the same field. Without them the success of Cooke and Wheatstone and later electricians would have been impossible. You will recall the great contributions of Œrsted, Ampère, Steinheil, Franklin, Schilling, Gauss and Weber, Volta, Henry, Morse, Faraday, Dyer, Edward Davy, Cromwell Varley, and many others, nearly all of whom have had the seal of death placed upon their lips, and their records have been left in our hands. We can well afford to be just to their memories.

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INCANDESCENT LAMP MANUFACTURE.—XIX.

BY J. SWINBURNE.

Exhausting Continued.

Fig. 21 shows an apparatus for exhausting. The lamp is sealed to the end of a short Sprengel tube, which is bent and sealed into a bulb. Enough mercury is put in the bulb to fill the lamp and leave a few ounces over. The whole is held in such a position as to leave a clear passage between the lamp and the tube with the tap, and the bulb and lamp are then exhausted as well as possible. The tap is then closed, and the apparatus is tipped till the mercury is run into the lamp; by tipping it backwards and forwards the air can be taken from the lamp into the bulb. The last small bubbles that remain can be got into the neck of the tube and the lamp full of mercury can be heated when expansion of the mercury takes them round. Though this looks easy it is troublesome in practice, as the apparatus is unwieldy when full of mercury. The vacuum produced was no better than that of the factory pumps. Unless the carbons are strong and the lamps sealed on so that the loop comes as shown, the mercury breaks the carbon. None of these experiments give promise of commercial success. The question of high vacua and the methods of testing them will be discussed under "Testing."

Fig. 21.

The vacuum for starting the pumps is supplied by mechanical pumps. There should be no difficulty in getting suitable mechanical pumps driven by power; but as a matter of fact it is, as there are no such things in the market, and they have to be specially made.

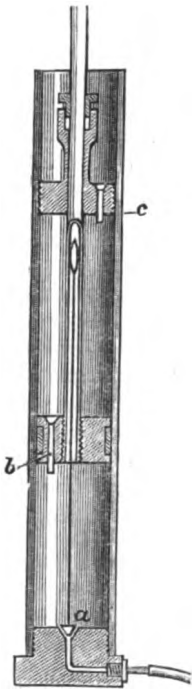

Fig. 22.

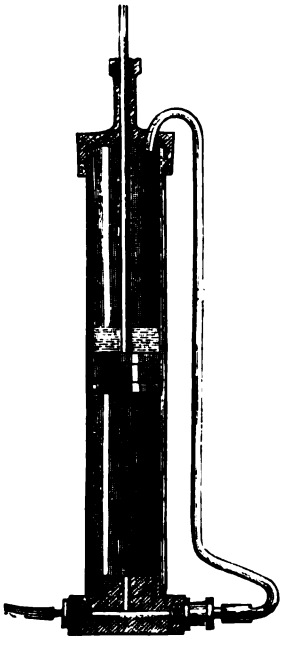

Fig. 23.

The simplest form is the ordinary silk valve pump, or exhausting syringe, as made by opticians. Several of these can be mounted and driven by power by means of a crank and connecting rod.

They are, however, very troublesome to keep in order, as little bits of dirt get under the silk valves, or the pumps get hot or leaky.

Fig 22 is a diagram of the pump that the writer used for some time. It is a modification of the pump used in Carré's hand ice machines.

As the piston rises the valve *a* is lifted by the friction arrangement which passes up the whole piston rod. When the piston begins to descend the valve *a* is closed, and kept shut by the friction of the rod. The piston comes down till it touches the bottom. If the pressure of the air has not already lifted the valve *b* in the piston it is lifted then, as the foot touches the bottom of the pump. The air left in the lower part thus gets out without being compressed by the effort of lifting a valve. When the piston rises the valve *b* shuts and *a* opens. When the piston reaches the top it opens the valve *c*. There is thus a vacuum produced both above and below the piston, so that when the lower chamber discharges through the valve *b* it discharges into a vacuum. These pumps will freeze water by exhausting over sulphuric acid. When driven by power they are apt to get out of order. The pistons cannot be packed with cap leathers, as there is a vacuum on both sides. The space at the top is filled with oil, so that if there is a slight leak the oil is sucked through and does no harm, as it is pumped out again.

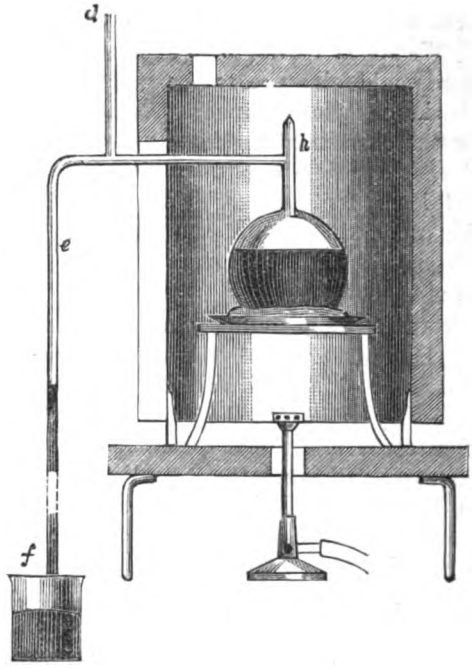

Fig. 24.

Fig. 23 is a diagram of a pump, that does not give such a good vacuum, but is easier to keep in order. The upper chamber is not utilised, and the long neck at the top is merely a guide, not being packed. Two oil-silk valves are arranged at the bottom. They can be screwed out without dismounting the pump. A few ounces of oil travel up and down on the piston; this keeps the pump well lubricated, and leaks through into the lower chambers. The delivery is connected with a pipe, which leads any oil that has leaked through back into the upper part.

The French make curious pumps, in which the cylinder is made of glass carefully ground true. The piston is made of a solid block of brass, turned a trifle smaller than the inside of the cylinder. At first sight one might suppose that such an arrangement would leak, but it does not. Air seems to flow with great difficulty through a very narrow crevice. The writer has used the Deleuil pump, which is made on this principle. This pump is not, however, suitable for factory work, as it is apt to run hot when driven continuously by power. It is unnecessary to describe the Deleuil pump here, as it forms a stock illustration in books on Physics. It is a beautiful piece of laboratory apparatus, and the workmanship is perfect.

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In Boston a Knowles steam pump was used. When the little brass pumps are used, one is used for every six pumps or so, so that each operator has her own pump, or else there is a pump between two, so that there is less chance of the vacuum being broken in the mercury pumps. With the Knowles pump, of course this practice was not followed, as one pump will work the whole pump room. This pump is used for exhausting the evaporating pans in sugar manufacture. The pump is a cylinder with a packed piston and india rubber or composition valves. The whole is flooded with glycerine, and there is a little adjustable bypass which allows the glycerine to leak slowly into the cylinder. The air and surplus glycerine are ejected every stroke, and the glycerine fills up all the little interstices. A 10in. pump was used for the pump room and a 7in. for the flashing room. The 10in. pump would preserve a fair vacuum even with a $\frac{1}{8}$in. hole open.

The mercury that is swept up from the floor is generally too dirty to be returned to the pumps. If it is merely dusty it may be run through a funnel; but generally that treatment is not sufficient. The methods given in books, such as squeezing it through chamois leather, shaking it up with sugar, or dilute acids, &c., are of no use. The mercury must be distilled. An iron retort, with a long delivery tube, is used. A glass reservoir will do. The retort may be heated by a large Fletcher burner. The receiver should be in water, and the whole must be under a chimney, so that the poisonous vapour cannot escape into the room. The surface of the mercury is covered with half an inch or so of iron filings. If this precaution is neglected the mercury will spurt over into the receiver, causing failure.

The writer much prefers to distil in a vacuum. His apparatus is shown in Fig. 24. It consists of a bulb about 3in. diameter. This is on a tripod stand in a cover like one of those used for keeping the lamps hot, but made of asbestos, not tin, so that any mercury spilled on it does not adhere. It is heated by a Bunsen burner. The tube *d* is connected to a hand mercury pump. The fall tube and the bend above it form the condenser, and the distilled mercury collects in *f*. To fill the bulb the tube *h* is opened. It would not be difficult to arrange a feeding tube so that the process would be continuous, but it is not worth while. A Sprengel fall tube was also tried so as to keep the mercury exhausted better, but it was continually cracking. The apparatus works well, but it must be kept going steadily, else the fall tube gets cold and cracks when some very hot mercury, newly condensed, runs down.

CORRESPONDENCE.

NON-POLAR DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Does not Mr. Snowdon's difficulty arise from a too materialistic conception of the "lines of force"? These have, I take it, no actual existence, but are simply a convention, useful as a graphic means of representing, by their number and direction, the condition of a magnetic field. To a given intensity and direction of magnetic force corresponds a definite distribution of lines of force; and any displacement of the magnet, whereby the intensity or direction of the field is not affected, causes, from the very nature of the lines, no alteration in their position or density. Thus, the rotation of a cylindrical bar magnet about its axis does not induce a current in a *fixed* metallic circuit placed in its field, because the number of lines of force which pass through the circuit are unaltered by the rotation of the magnet, the field being symmetrical about the axis.

So in the Forbes dynamo, the magnetic field is, from the construction of the machine, symmetrical about the axis of rotation, and under fixed conditions of speed, &c., it is also constant; hence the lines of force cannot be said to rotate. The external iron sheathing is, as Mr. Snowdon says, as much armature in a sense as the rotating iron; but it is a stationary armature, and therefore, situated as it is in an invariable field, useless for the production of current. If the machine could be so arranged that this external "armature" were made to revolve as well as the armature proper, a current could, by suitably arranged rubbing contacts, be drawn from it also.—Yours, &c.,

BERNARD P. SCATTERGOOD.

London, July 2nd, 1887.

"NONPOLAR" DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In De la Rive's "Electricity," Vol. I., page 435, there is an account of an interesting experiment which is something like this:—A cylindrical magnet, Fig. 1, is mounted axially in a horizontal position by pivots running in bearings. At its equatorial part a flange is fixed, whose outer edge dips into a mercurial cup as it and the magnet revolve. A similar flange is fixed at the end of the magnet. A sufficient speed is given to the magnet by the crank handle, pulley wheel, and strap. The wires from a galvanometer dip into the two mercurial cups respectively, as shown. By the rotation of the magnet the needle is deflected, proving the existence of a current. The direction of current reverses as the direction of movement is reversed. Now, how is this? De la Rive says the current is produced by the "moving" lines of force cutting that part of the stationary conductor which leads to the galvanometer. But there would be no difficulty in arranging these conductors so as to be practically parallel with the lines of force, and in that case it is difficult to see how the wires could be in any way affected. The question rather appears to be this:—When the magnet revolves does the magnetism, or do the lines of force, revolve with it? If they do, it seems impossible that a current should be generated. If, on the other hand, the magnetism is regarded as separate from the iron, and as a fixed element uncontrolled by the iron, only so far as it is held in it as a mass, then the possibility of a current presents itself at once, for in that case every molecule of iron would cut the magnetism in the most favourable direction for producing a current.

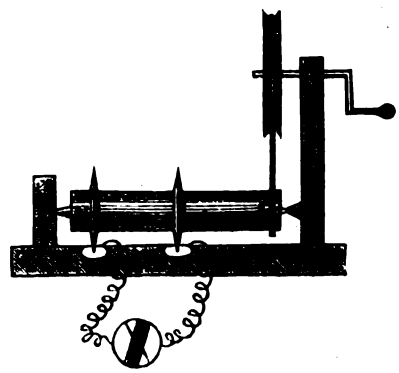

FIG. 1.

In a letter of mine which appeared in your journal on October 13, 1883, I drew an analogy by likening a cylindrical bar magnet to a similarly-shaped vessel containing water. The water was intended to represent magnetism, and, moreover, for convenience, it was supposed to possess lines of force in all respects the same as a bar magnet. If such a cylinder were rotated in the same way as the magnet in the above experiment, it is easy to see that the water and its imaginary lines of force would be held stationary by gravitation. To make the analogy plainer I conveniently ignored the friction of water against the sides. It is evident that the vessel as it revolved would intersect all the lines of force precisely in the same way—according to this theory—as does the revolving magnetised iron in the experiment (Fig. 1).

Faraday carried out a series of experiments involving the same phenomena in quite a different way. As most of your readers are probably acquainted with them I will only just notice them. In his method he employed a jar of mercury, and immersed the magnet in it up to its equatorial part. One collector was applied at this point, and the other at the top of the magnet. Faraday's explanation in this case was that the

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lines of force passing through the mercury generated the current, so that even he evidently thought that the magnetism was rotated with the magnet, and that a stationary conductor was essential. But we have it in his own words that a definite result was obtained by suspending a magnet by a thread and sharply spinning it round in the air while collectors were properly applied. Surely there was no stationary conductor in this experiment, the action being the same as Fig. 1.

From the simple magnet (Fig. 1) it is but a step to the electro-magnet, when the conditions for my theory would appear to be more favourable, the iron molecules being more magnetically porous, if I may be allowed the expression, and the magnetism more powerful. I think it is generally admitted that the distribution of lines of force in the core of an electro-magnet are longitudinal or parallel to its length. It is convenient in the present case to have the cores of considerable diameter, and if two such electro-magnets be placed side by side and their ends magnetically closed by iron they may be made to form a closed magnetic circuit as shown in Fig. 2. The cores may be capable of rotation in the solenoids, and are formed of discs of iron and copper insulated from each other, but mounted on, and in electrical contact with, the spindles. By connecting all the peripheries of the discs to longitudinal rods the whole of the radial currents developed in the rotating system may be taken off by having contact at the spindle and at the periphery. I have designed a dynamo on this principle in which both the solenoid and core rotate, the wires to the solenoid being led up the spindle, and terminating in flanges immersed in cups of mercury.

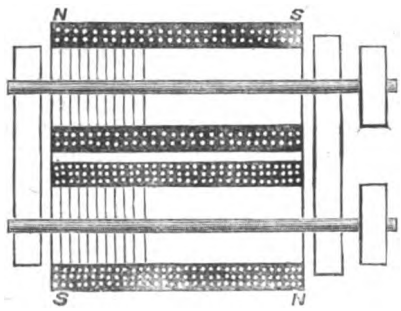


FIG. 2.

It will be seen that there is a difference between the experiments Fig. 1 and Fig. 2. It is this. In the former the chief cause of the current is the outer surface of the magnet intersecting the curved lines of force as they come out of one pole to return to the other pole in air; whilst in Fig. 2 there is practically none of this external magnetism, it being all confined to the cores. With reference to the Forbes dynamo, Mr. Snowdon says:—"What prevents the lines from going round with the armature?" If this theory which I have ventured to propound be correct the question is unnecessary.

The earth has often been compared to a magnet, which it no doubt really is. Query—Does terrestrial magnetism rotate with the earth, or is it fixed in space while the earth rotates through it? At the first glance it would seem that, inasmuch as terrestrial magnetism is probably produced by the earth, it would be expected to rotate with it. But if, with regard to the universe, it were stationary or a fixed element independent of, although caused by, the earth, then, to us, it would appear to move; whilst if it rotated with the earth it would, to us, be stationary. It is only by comparison that we know anything, and it would appear to be necessary, in order to solve this problem, that some other magnetised earth body would have to be taken into account.—Yours, &c.,

London, July 5th, 1887. E. L. VOICE.

ADMIRALTY DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 1st inst. you publish the Admiralty specification recently issued for dynamos and engines, and, commenting thereon, question whether 20°F. is not an almost impracticable limit for the increase of temperature in the machines. An extensive experience with dynamos of most sizes and types enables me to say that the limitation specified is not only impracticable, but, under ordinary conditions of weight, impossible. No dynamos have been yet constructed which will satisfy the conditions named, nor is such construction possible unless the ratio of weight to output far exceeds any limit which the Admiralty would be likely to allow.—Yours, &c.,

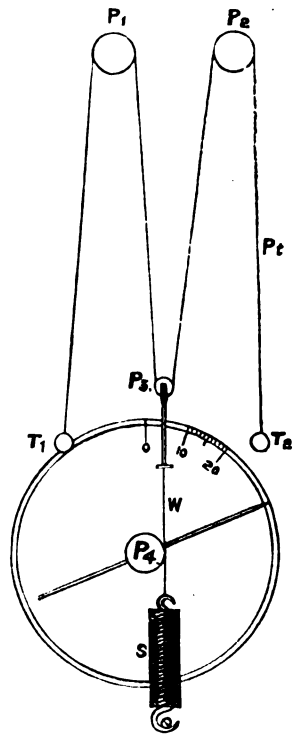
W. B. ESSON.

London, 4th July, 1887.

CARDEW'S VOLTMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would some reader having a knowledge of the aforementioned instrument say if the modification as per sketch herewith be practicable? A platinum wire, P*t*, runs from terminal T_1 over pullies P_1 P_2 and P_3 to terminal T_2. A wire,



W, from P_3 to the spring S drives by friction the pulley P_4. Supposing the length of the platinum wire to be 12ft., what gauge would be most suitable? Would it be advisable to increase the traverse of the index finger by a wheel and pinion? The instrument is required to read up to 130 volts or thereabouts. Trusting some reader will oblige.—Yours, &c.,

June 25, 1887. J. H. H.

NOMENCLATURE.—MAC; USE OF *PER* AND *BY*; INTENSITY AND DENSITY; SCIENTICULOMETER; GRAMMATICULIST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With your permission I would like to add a few remarks on the never-ending subject of nomenclature.

Mac.—I would be obliged by information regarding any reason that can be stated against the use of the word mac as the name of the practical unit of inductance. I mean, of course, a reason that has a backbone in it. I think it possesses to an unrivalled extent all the qualifications, positive and negative, that it is desirable the name of a practical unit should possess.

Use of *Per*.—Coals, twenty shillings per ton, means that the price of a ton of coals is twenty shillings. Now if we divide the price expressed in shillings of any quantity of coals by the

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quantity expressed in tons, we obtain the number twenty, the price in shillings of a ton. I do not think, however, that the coal purchaser goes through this process, but that he or she goes the other way to work, and on seeing that coals are twenty shillings per ton, thinks immediately of the sum of money twenty shillings, and of the quantity of coals in a ton; and to obtain the price of any quantity of coals, multiplies the number of tons by the price per ton. I am induced to make these very elementary remarks by observing that some writers seem to use *per* to signify "divided by," and nothing more. This practice reaches its climax when the word unit, or the name of the unit itself, is omitted, and it is said, for instance, not that the inductance of a circuit is the momentum per unit current (which is similar to the phrase twenty shillings per ton), but that inductance is momentum per current. If this were all, my remarks would have the usual value of verbal twiddling; but they serve to lead to the real point, which is, the use of *per* in an extended sense. If I say, to avoid circumlocution, that conductivity is the conductance per unit volume, or that resistivity is the resistance per unit volume (not "per volume" observe), I think that what is meant is so immediately obvious that no one thinks of examining whether this use of *per* conforms to the rule, per = divided by. In fact it does not. Yet conductivity is the conductance of a unit volume. I think, therefore, that the use of *per* in the extended sense, which is very convenient, may be permissible.

Use of *By*.—In comparison, it is a very trivial matter, whether we use *by* to signify "divided by" or "multiplied by." My preference is toward the former practice. I would prefer that *into* should signify multiplication. Thus, E by R equals C; and E into C equals activity.

Intensity and Density.—There is usually so marked a physical distinction between a force and the corresponding flux that I think it would be as well to consistently recognise it by applying the word "intensity" to the force and "density" to the flux. This is already generally done as regards forces, and it is becoming common as regards one flux, electric current. In respect to the flux energy-current, which has no force to match, I would speak of its density, because it is not merely nominally, but really a flux.

Surface-integral of a Flux.—Sometimes the distinction between the flux and the force is lost (generally in theoretical investigations in which false conditions are assumed to exist), and then we have surface-integrals of forces. I am, however, convinced that it is well to keep as much as possible to physical ideas, which lead us to line-integrals of forces (intensities of) and surface-integrals of fluxes (densities of).

Scienticulometer.—This word must define itself. I have given a preliminary account of my recent researches with the scienticulometer in a memoir, which is not yet published. Some of my results, however, have been already given by Prof. S. P. Thompson.

I have also endeavoured to apply this instrument to the investigation of a quite new phenomenon, which I may term, provisionally, the learned grammaticulist. Up to the present time, however, I have failed to extract anything but froth, with a parting smack of vulgarity (*see* p. 161). This is disappointing. Froth is excellent in its way, but is rather too insubstantial. As for the other, it is certainly not the proper thing to use, especially for so accomplished a literary critic, who should, I think, endeavour to copy the refined style of Addison and other polite writers.—Yours, &c.,

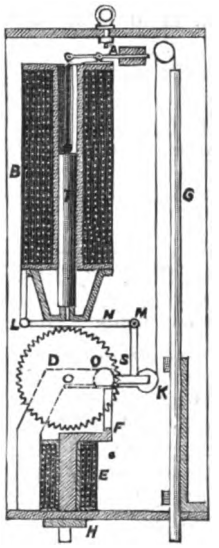
OLIVER HEAVISIDE.

ELECTRIC PORTABLE LAMP.

In connection with our notice of this battery M. Friedländer writes:—"Will you have the extreme kindness to add a few remarks in your next issue. The solution used in my lamp battery is entirely different from any yet known preparation of potassium bichromate. My solution affords one regular and constant current for several hours. The zinc plates always remain amalgamised, and need never be cleaned. When used up to a certain extent the zinc rods can be removed and new ones replaced by anyone in less than five minutes. One principal advantage with my new lamp is the simplicity. Recharging is as simple and easy as with an ordinary petroleum lamp. The lamp can be lit by simply turning the knob, because the lamp can be kept with battery charged any length of time, and be at hand any moment. The light can be regulated from 2 to 4 candle-power."

THE HARDT ARC LAMP.

The adjoining figure shows the mechanism of an arc lamp designed by M. Hardt, and described in *La Lumière Electrique*. B is a solenoid connected in shunt, and containing a hollow core, T, which carries at its lower extremity a catch which engages with the teeth of an iron wheel, D.



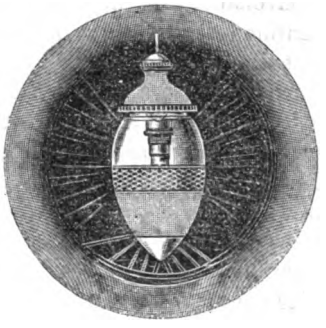
E is an electro magnet in series in the main circuit. This magnet has an armature in the form of a bent lever, F, which is pivoted at O, and is pulled down when the current is switched on. This lever carries the pulley K, over which passes the cord which supports the upper carbon holder G. The piece M is connected to F, and the lever N is articulated at M and at L. H is the lower carbon holder. The cord supporting the upper holder is wound around the axis of the wheel D.

The carbons being in contact, when the circuit is closed the lever F is pulled down by the magnet E and the upper carbon is raised, striking the arc. At the same time the lever N is also pulled down, and the core T, which was previously upheld by N, engages with the toothed wheel D, and checks its rotation.

As the arc elongates the solenoid B is more powerfully excited, until at length the core T is again raised and the wheel released. The movement is retarded by means of a lever and counterpoise connected with the core. When T is thus raised the weight of the upper carbon and holder is sufficient to cause the rotation of the wheel D and the consequent shortening of the arc. This, however, is prevented from taking place too rapidly by the braking effect of the magnet E upon the iron wheel.

LEA'S ORNAMENTAL GLOBES FOR INCANDESCENT LAMPS.

Messrs. Fowler, Lancaster and Co. are introducing a globe for enclosing incandescent lamps, which is represented in the adjoining figure. Of course, the object of such an attachment is to conceal the filament itself from the eye, while intercepting the light as little as possible. Both the globe and its cover are made entirely



of glass, and there are no metallic rims or screws to work loose, the connection being of an elastic character. The method of attachment adopted relieves the electrical connections of the lamp-holder from the weight of the globe. So far as can be judged from the figure, this globe will probably strike most of our readers as being particularly well designed from the æsthetic point of view.

ENTOMOLOGICAL ADVANTAGES OF ELECTRIC LIGHTING.—It has been observed in Ottawa, Canada, that the introduction of the electric light in street illumination has facilitated the collection of entomological specimens, particularly of rare species, as insects of all kinds are attracted to the lamps in large numbers.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Cheques and P.O. Orders to be made payable to C. H. W. BIGGS.

Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE BANQUET TO PROF. TYNDALL.

The large and distinguished gathering at Willis's Rooms last week to do honour to Prof. TYNDALL on his retirement from the Chair of Natural Philosophy in the Royal Institution was an event which, although in the highest degree complimentary to him personally, may also be taken as a notable recognition of scientific research which he has so long and so brilliantly represented. Hardly less so are the ungrudging praises bestowed upon his career by the daily press. Not so very many years ago neither the banquet nor the newspaper articles would have been possible. Prof. TYNDALL has generally worked upon contested ground; and it has been his lot in times past to come in conflict with the most cherished convictions of his countrymen. The recollection of these feuds, however, has been wiped away, partly no doubt by his own singular powers of persuasion, but partly also by the spread of scientific knowledge which has reconciled the world to his teaching by making it less novel and startling. Formerly he was pointed at as a dangerous man, and a warning example of what science was tending to; to-day he is the honoured guest of all shades of politics and almost all shades of religious belief. If the strictly theological element was not there, it was more because its presence might have been misunderstood than from any prejudice against science, or any want of respect for one of its greatest modern exponents.

Prof. TYNDALL'S own speech on the occasion referred to has naturally formed the chief subject of public comment, and we need not go over the same ground here. It was a lucid and eloquent discourse, and a fine example of that literary talent which has done so much to make science in these days a popular and attractive study. But, as bearing on our remarks above, the other speeches which followed were equally noteworthy and instructive. There was the speech of the Statesman in the person of Lord DERBY, and that of the Man of Letters represented by Lord LYTTON. "The Public Services in Relation to Science" was handled by Sir LYON PLAYFAIR, who, if not distinguished as a public servant or a man of science, is a sufficiently conspicuous representative of the Politician. We do not know in which capacity it was that he deplored the loose connection that existed between Science and the Government; but if he spoke as a politician he got very little countenance in the person of Lord DERBY, who replied on behalf of the State. With regard to the common complaint that our statesmen have done so little for science, Lord DERBY retorted that "they had done the best they could for it—they had let it alone; they have not corrupted it by their intrigues, nor vulgarised it by their squabbles; and they being what they are, and science being what it is, that is probably the best service they could have rendered it."

Now, in this blunt expression of the practical statesman we should imagine Prof. TYNDALL would himself concur. Possibly Sir LYON PLAYFAIR meant technical education, while Lord DERBY had in his mind the kind of education represented by their illustrious guest. Certainly Prof. TYNDALL'S own language does not lend itself readily to the State patronage of science. He extols the pursuit of truth for its own sake, and the steady application to scientific research, without the least regard to its utilitarian aspect, as the highest vocation to which a man can devote himself; and it is pretty obvious that you cannot claim the merit and seek the reward at the same time. We say seek it, because, of course, in certain circumstances, it may be the duty and the highest privilege of the State to confer that which is not sought. An instance of this kind was furnished in the career of FARADAY, whom we feel sure Lord DERBY would not have "let alone" in the sense of leaving him unfriended and penniless. Probably what the practical politician means is that it will never do to make Science the object of political patronage; and that this is certainly a danger which would be incurred by making the relations between Science and the State less "loose" than they are at present.

Perhaps the advocacy of State patronage is rendered rather more than less difficult by the transcendental aims and motives ascribed to the pursuit of science by men like Prof. TYNDALL. We are not for a moment questioning their sincerity; on the contrary, we are confident that their ruling motive is as far removed from selfishness as any human passion can be. But it is clearly not a cry upon which one can "appeal to the country," though an excellent one for an appeal to the conscience. "I do not know and I do not care whether my discoveries are, or may ever be, of any use," says the ideal philosopher, according to Prof. TYNDALL. "Very good," remarks the common-place world; "you satisfy your notion of duty, you cultivate the special aptitudes which you are conscious of possessing, and you gratify your thirst for knowledge; but you are by no means sure or anxious we should get any benefit by your industry. That being so, really the best thing we can do is to 'let you alone;' for if we were to endow you we should run two serious risks, the one of corrupting you, the other of paying for what, according to your own showing, may be of no value." *The Times* is evidently per-

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plexed by the problem here presented by this lofty standpoint of science, and solves it in the usual way, by ascribing to science its highest value as an educational instrument. But surely this is reducing it to the level of mathematics or the study of the classics. Natural philosophy may be superior to either of these as a trainer of the mind; but this is not the matter in question. The votaries of scientific research have not followed it as a lifelong vocation merely in order to train their minds. If that were the case their education would be exclusively their own affair; and we instinctively feel that it is not exclusively theirs, but is ours as much as, and even more, than theirs. In our judgment it would be well to drop, in some degree, this talk about superior motives, and dwell a little more upon the superiority of results. The motives in this cynical and time-serving age may be called in question; but the utilitarian side of scientific research can be confidently asserted by its professors, and is not likely to be contradicted by the non-scientific world at large. The world, indeed, feels itself profoundly indebted to the class of man of whom Prof. TYNDALL is a shining example; but the debt will be more cheerfully paid if his services, rather than his virtues, are made the subject of laudation.

EFFICIENCY TESTS OF A GAULARD AND GIBBS TRANSFORMER.

BY P. CARDEW, CAPTAIN R.E.

From *Industries*, July 1.

The excellent articles by Mr. Kapp on the determination of the lag of primary current behind impressed E.M.F., and of magnetisation behind primary current in a transformer, have been of great service to me, as I happened just at the time that they appeared to be engaged in determining the efficiency of one of these instruments, specially wound and submitted for test by the company connected with Messrs. Gaulard and Gibbs. I was preparing to wrestle with the problem myself when I found this labour saved by the articles mentioned, and as a slight return for this benefit I give herewith the tests taken, with the lags worked out and expressed as angles, and the external efficiency deduced. The tests do not pretend to anything like exact accuracy, as time and the present importance of the question to the War Department did not permit of elaborate precautions being taken. Nevertheless, and in spite of considerable variation in all the quantities measured, the resultant efficiencies are very close, and the sum of the angles ϕ and ψ still more strikingly close in all the tests. The turns of the primary and secondary conductors were to each other in the proportion of 4:5, which obviously would not be suitable for a practical instrument, but which was very convenient for our means of measuring. The weight of the transformer was about 90lb.

The angle ϕ is the lag of primary current behind E.M.F., as used by Mr. Kapp in discussing a single magnetic coil. I think it is a pity that he called this ψ in discussing a transformer; ψ is the lag of magnetisation behind primary current. The efficiency is

$$\frac{\text{Secondary current} \times \text{secondary E.M.F.}}{\text{Primary current} \times \text{primary E.M.F.} \times \cos\phi}$$

The resistance of the two coils was: Primary, ·023ω; secondary, ·036ω. This indicates equal mass of each conductor, in which case the resistances should be to each other in the proportion of the square of the conversion factor, not in the simple proportion, as I think I have seen it stated. The calculated external efficiencies are certainly too high, for the following simple reason, as pointed out by Mr. Kapp, viz., whatever power is absorbed by the iron core should be expressed as current × E.M.F.; the current must oppose the magnetisation, and its ampere turns should be added to those of the secondary current in calculating ψ, making ψ greater and ϕ less than as now calculated. This, of course, will make the number of watts in the primary somewhat higher. It is quite hopeless, I think, to attempt this correction; but, from estimating the radiation from the core, I should put the power wasted at full load at about 2½ per cent., leaving an efficiency of conversion of 97·5 per cent.

However this may be, I consider the results undoubtedly show a very high efficiency for these transformers, and I must say that, in my opinion, great credit is due to Messrs. Gaulard and Gibbs and the company connected with them for what they have done in the face of every sort of discouragement to perfect the system, which I am convinced has a great future before it.

The interchange of energy between the transformer and the supplying circuit is a curious phenomenon. When ϕ is appreciable the transformer begins to return energy during a portion of each alternation, and when $\phi = \frac{\pi}{2}$ the energy given to the transformer during one quarter of an alternation is returned during the next quarter, except what is exhausted in heating the conductor. There is a sort of ebb and flow of tide enduring in the case of the last experiment but one, for about $\frac{1}{600}$th second, and only a little leaks out each time. In this experiment the calculated primary watts are 55·4, of which 40·57

EFFICIENCY TESTS OF A GAULARD AND GIBBS TRANSFORMER.—TABLE OF RESULTS.

Number of Lamps in Secondary Circuit.		Current.		Volts.		Angles of Lag.									External Efficiency.
		Primary.	Secondary.	Primary.	Secondary.	ϕ			ψ			$\phi+\psi$			
						deg.	min.	sec.	deg.	min.	sec.	deg.	min.	sec	Per cent.
First Series.....	20	55·3	40·6	50 5	61·	22	26		67			89	26		95·9
	11	42·4	23·1	50·5	60 25	46	16	30	42	55	20	89	11	50	94·
	7	40·4	15·3	50·5	61·5	60	49	10	28	15	10	89	4	20	94·6
Second Series.....	14	43·9	28·8	46·75	55 75	34	12	10	55	5	20	89	17	30	94·6
	21	52·3	38·16	43 5	50 5	23	50	30	65	30		89	20	30	92·6
	17	53·5	33·5	47·	55·5	37	33	20	51	30	30	89	3	50	93·27
	13	38·2	25·14	45·	54·5	34	0	50	56	21		89	21	50	96·16
	9	33·3	17·35	47 25	57·	48	39	25	40	38	15	89	17	40	95·15
	23	60·2	40·2	42·5	50·	32	23	10	56	35	10	88	58	20	93·
Third Series	23	56·7	41·83	43·5	51·5	22	8		67	12		89	20		94·3
	15	49·	34·04	52·	63·5	29	7		60	16		89	23		97·15
	12	46·4	29·81	56·	68·5*	35	58	45	53	25	25	89	24	10	89·39*
	9	42·9	20·39	50·	60·6	52	39	50	36	26	40	89	5	30	95·
	6	41·1	16 68	56·	69·5	58	41		30	29		89	10		96·94
	3	39·6	7·9	64·	79·	74	46	10	14	26	25	89	12	35	93·74
	0	41 8	·2†	61·2	77·	88	45	25	0	20	35	89	6		27·76†
	6	41 9	16·32	50·25	61·33	59	54	10	29	8	10	89	2	20	94·8

* Primary volts probably read too high. † Estimated current in voltmeter.

NOTE.—The dynamometers were very insensitive for the currents used, it being considered desirable to avoid self-induction in them.

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are absorbed in the primary coil, and 15·4 in the secondary circuit, so that in this case we get an apparent efficiency of conversion of $\frac{55·97}{55·4}$, just over 100 per cent., but of course this should be reduced on account of the power absorbed by the iron core. The fact that the primary current absolutely rose to a higher value in this experiment as compared with the previous one is very curious.

The primary circuit was connected to a 32-magnet Wilde machine, the secondary circuit to 50 candle-power 60-volt lamps. In the first series the volts at machine were maintained constant by the engine driver altering his speed to suit the load, and the tests were taken on one Siemens electro-dynamometer and one Cardew voltmeter, by rapidly changing the instruments from one circuit to the other. In the second series an attempt was made to keep the speed constant by altering the strength of field in the machine; but as no suitable rheostat was available, and the engine was not governed this could not be exactly effected, and the volts on the primary circuit show considerable variation. Two dynamometers and two voltmeters, however, were used, so that absolutely simultaneous readings were secured. In the third series no attempt was made to keep any value constant, but simultaneous readings were taken. The angle ϕ is the lag of primary current behind impressed E.M.F., ψ that of magnetisation behind primary current; their sum, as shown, is in all cases nearly 90°.

ON THE SUPPOSED "NEW FORCE."

At one of the May meetings of the Royal Society Mr. Crookes discussed the supposed "New Force" of M. J. Thore, whose experiments led him to believe in the existence of a new force inherent in the human organism. M. Thore suspends a small cylinder of ivory by a fibre of cocoon silk forming a small pendulum which hangs freely over the centre of a table. The cylinder having become motionless, M. Thore brings a second cylinder, called the "pillar," about a millimetre from the first cylinder, when the latter begins to rotate clockwise if the pillar is on the left, and counter clockwise if the pillar is on the right of the cylinder. The observer is supposed to face the cylinder and pillar. M. Thore says that the rotation is independent of the nature of the cylinders, of their mass, or the dimensions of the pillar; light, heat, electricity, magnetism, gravity, and air currents, he says, are also inadequate to explain the phenomena.

Mr. Crookes repeated M. Thore's experiments, and came to the conclusion that the action is one of radiation from the face or other warm body in front of the apparatus, and that there is nothing special in the human organism beyond the heat it radiates to produce rotation of the cylinder.

Mr. Crookes's experimental results were sent to M. Thore, who replied that the dynamical explanation was not sufficient to account for more than a few of the facts he describes, and saying that he "persists in still believing that this force emanates from the observer, or else that the observer is the indispensable intermediary for its manifestation." In reply to this Mr. Crookes states that although he experimented in an enclosed space, while M. Thore experimented in free air, and thinks that enclosure may almost or quite suppress force, he has verified nearly all M. Thore's facts of rotation by his method. He had verified the facts of rotation when working in the free air of a large room, and it was only when he found the delicacy of the observations was impeded by draughts and currents that screens were put round the apparatus.

It may be wondered why we mention experiments which are not directly electrical, but as—as will have been seen from our correspondence columns—Dr. Shettle maintains that the results obtained are directly due to electric or magnetic influence, and not to heat radiations, our readers may be perhaps interested in obtaining from Dr. Shettle a brief account of the experiments he has carried out in this direction.

NOTE ON THE ELECTRO-DEPOSITION OF ALLOYS, AND ON THE ELECTROMOTIVE FORCES OF METALS IN CYANIDE SOLUTIONS.*

BY SILVANUS P. THOMPSON, D.SC., B.A.

It is known that the electro-deposition of such alloys as brass, bronze, and German silver is not practicable from mixed solutions of the sulphates or chlorides of the constituent metals, but can be accomplished by using cyanide solutions or neutral solutions containing cyanide of potassium in excess, thereby apparently departing from the law of Berzelius, that out of a solution of mixed metals the least electro-positive metal is deposited first.

To ascertain the cause of these facts the author has investigated—

(*a*) The electromotive forces of a number of metals in aqueous solution of cyanide of potassium.

(*b*) The dependence of these electromotive forces, in particular those of copper and zinc, upon the degree of concentration of the solution.

(*c*) The variation of the electromotive forces of copper and zinc in a standard solution of cyanide of potassium at varying temperatures.

(*d*) The electromotive forces of zinc and copper in a "brassing" solution, consisting of the mixed cyanides of zinc and copper, having excess of cyanide of potassium present, and their variation at different temperatures.

It is found that the effect of higher concentration of the cyanide solutions is invariably to increase the electromotive force of copper more than it increases that of zinc.

In a cold dilute solution of cyanide of potassium the electromotive force of zinc against carbon is 1·158 volt, while that of copper against carbon is 0·948 volt, or zinc is 0·210 volt higher than copper. In a boiling saturated solution of cyanide of potassium, the electromotive force of zinc against carbon is 0·768 volt, and that of copper against carbon is 1·300 volt; or copper is 0·532 volt higher than zinc.

It is therefore possible to construct a voltaic battery containing one metal only, namely, copper, and one electrolyte only, namely, an aqueous solution of cyanide of potassium, kept hot at the anode and cold at the cathode of the cell.

In cyanide solutions, containing about the following number of grms. of cyanide to the litre, the following were the electromotive forces observed with a carbon cathode:—

Solution containing per litre 99·4 grms.		191·4 grms.		1·18 grms.	
		Metals at 18° C.			
Zinc	1·520	Copper	1·434	Zinc	1·13
Copper	1·425	Zinc	1·401	Brass	0·58
Brass	1 400	Brass	1·315	German silver	0·50
German silver	1 05	German silver	0 936	Lead	0·44
Gold	0·885	Gold	0·834	Copper	0·39
Silver	0 845	Silver	0·810	Silver	0·39
Lead	0 64	Lead	0·609	Gold	0·34
Iron	0·47	Iron	0 181	Steel	0 30
Steel	0·44	Steel	0·161	Iron	0 30
Platinum	0 27	Platinum	0·017	Platinum	0 14
Carbon	0	Carbon	0	Carbon	0

Several of the metals exhibit maximum electromotive force at an intermediate concentration.

The following figures were obtained for zinc and copper in solutions of cyanide of varying strengths at 17° C.:—

Grms. per litre.	E.M.F. zinc.	E.M.F. copper.	Difference Z—C.
2·9	1·158	0·948	+0·210
5·9	1·167	0·967	+0·2 0
11 2	1·184	1·018	+0 166
23·8	1·221	1·058	+0·163
47·7	1·269	1·130	+0·139
95·5	1·303	1 220	+0 080
191·1	1 355	1·360	−0·005

In a mixed solution of cyanides of zinc and copper there is a neutral condition where the electromotive forces of zinc and copper are equal, and this neutral condition varies with the relative amounts of metal present, with the concentration of the solution, and with the temperature. The neutral temperature for a solution of given concentration is lowered by adding cyanide of potassium, and is raised by adding ammonia. The neutral point, however, is not well defined, the behaviour of copper being very uncertain; in general the electromotive force of clean copper in a cyanide solution rises, in some cases, as much as 0·06 volt, in a few seconds after immersion, but is rapidly though temporarily lowered on agitation.

Since the degree of concentration of the solution greatly affects the electromotive force of the metal, and since, in the act of deposition of a metal from its solution, the concentration of the liquid around the cathode is reduced, owing to slowness of diffusion, it follows that in electro-deposition the counter electromotive force at the cathode will vary with the rate at which metal is being deposited, and will therefore vary with the current-density employed. And since, moreover, the variations in electromotive force due to differences of concentration are greater for copper than for zinc, it follows that in the deposition of brass from a mixed solution of cyanides of a medium concentration, in which zinc is slightly more electro-positive than copper, there will be a certain density of current with which the metals will be deposited in nearly equal quantities, while for weaker current densities the less electro-

* Paper read before the Royal Society, June 16, 1887.

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positive metal will be deposited in excess, and for stronger current densities the more electro-positive metal will be deposited in excess.

Hence, to variations in the concentration of the electrolyte near the cathode are due the departures, observed with all currents except weak ones, from the law that out of a solution of mixed metals the least electro-positive is deposited first.

THE DRIVING OF DYNAMOS WITH VERY SHORT BELTS.*

BY PROFS. W. E. AYRTON, F.R.S., AND JOHN PERRY, F.R.S.

When fast-speed machines, such as dynamos, are driven in the usual way by belting, there is a certain waste of power in overcoming the friction that is set up between the driven spindle and its bearings by the tensions necessary to be given to the two sides of the belt to produce the required grip on the small driven pulley. This waste of power is usually kept small by using a long belt and putting the dynamo at a considerable distance from the large driving pulley, and thus obtaining a large angle of contact with the belt with the small driven pulley. But such an arrangement is very inconvenient to employ on board ship or in the guard's van of a railway train or elsewhere, when the space is confined, and a short belt would always be employed were it not that the small angle of contact of the belt with the driven pulley, that would be produced if the small pulley was put close to the large driving one, would necessitate the tension on the belt being large. And this large tension would cause considerable pressure on the bearings, leading to a considerable waste of power in overcoming friction; further, the belt would be much stretched, requiring constant adjustment of the dynamo to tighten it to avoid slip. And further, the occasional stretching of the belt produced by atmospheric changes would make the belt slip were the tension when the belt shortens again not far greater than is necessary for driving purposes. Hence the average tension of such a belt must be made to far exceed what a simple calculation of the necessary driving tensions would give, and the waste of power is in consequence also much in

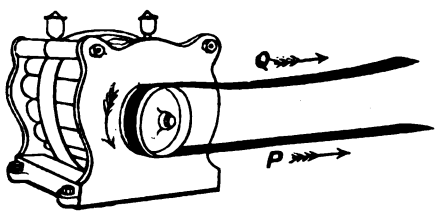

FIG. 1.

excess. Indeed, this is the reason why belting is usually placed more or less horizontal, and why long belts are employed with the upper side the slack side, so as to introduce a weight compensation, as seen in Fig. 1.

Similar difficulties occur when an electro-motor, or other fast-speed motor, is used to drive machinery by means of belting.

Very many plans have been tried of overcoming this difficulty. For example, to increase the angle of contact of the short belt with the small driven pulley, and to keep the belt tight, Messrs. Mather and Platt used a large tightening pulley with their compact engine and dynamo at the Inventions Exhibition, and also now at the Manchester Exhibition.

In transmitting power from an ordinary steam engine to a dynamo, or from an electro-motor to a tool, we have to gear a slowly and a fast rotating shaft, and the problem of doing this in a limited space, and with small loss of power in overcoming friction, has led to the many forms of "*friction gearing*" that have from time to time been devised. Indeed, one part of the joint work in telpherage carried out by the late Prof. Fleeming Jenkin and ourselves was the designing of many modifications of such friction gearing, or, as it has been called, "*nest gearing*," for enabling power to be transmitted between a slowly and fast rotating shaft by means of a *pure couple without side thrust*. To enter into even a short description of these many forms would take up too much of your time; but we may mention that those interested in the subject will find descriptions of some of them in papers read before the Society of Arts and the British Association. The great objection to the employment of such friction gearing is the expense of construction, since adjustments have to be introduced to take up the wear of the rolling pulleys, which is considerable; hence, in spite of the ingenuity of friction gearing, from a mechanical point of view, and of the captivation it has for those who are concerned with this problem of transmitting power between slowly and fast rotating shafts, it has not come into general use.

You are probably familiar with the form of friction gearing employed by Messrs. Siemens† for driving dynamos. The dynamo is balanced so as to turn on an axis at right angles to the axis of rotation of the armature and the dynamo pulley; the pulley is made of compressed paper, and rests on the top of the fly-wheel of the engine. The arrangement is good, since the force pressing the pulley against the rim of the fly-wheel is not all transmitted through the bearings, but is partly furnished by the weight of the dynamo pulley. But this form of friction gearing has the following objections: First, the paper pulley has to be constructed in a very special way, under hydraulic pressure, and is necessarily much more expensive than an ordinary cast-iron pulley. Secondly, the fly-wheel of an ordinary engine cannot be employed without having first its rim turned up true. Thirdly, the axes of rotation of the armature and fly-wheel must be placed accurately parallel to one another, otherwise there is a grinding action at the surface of the paper wheel, which destroys its surface. Next, it is a mistake to place the dynamo so that the paper pulley rests on the very top of the fly-wheel, since with this arrangement there is necessarily a side

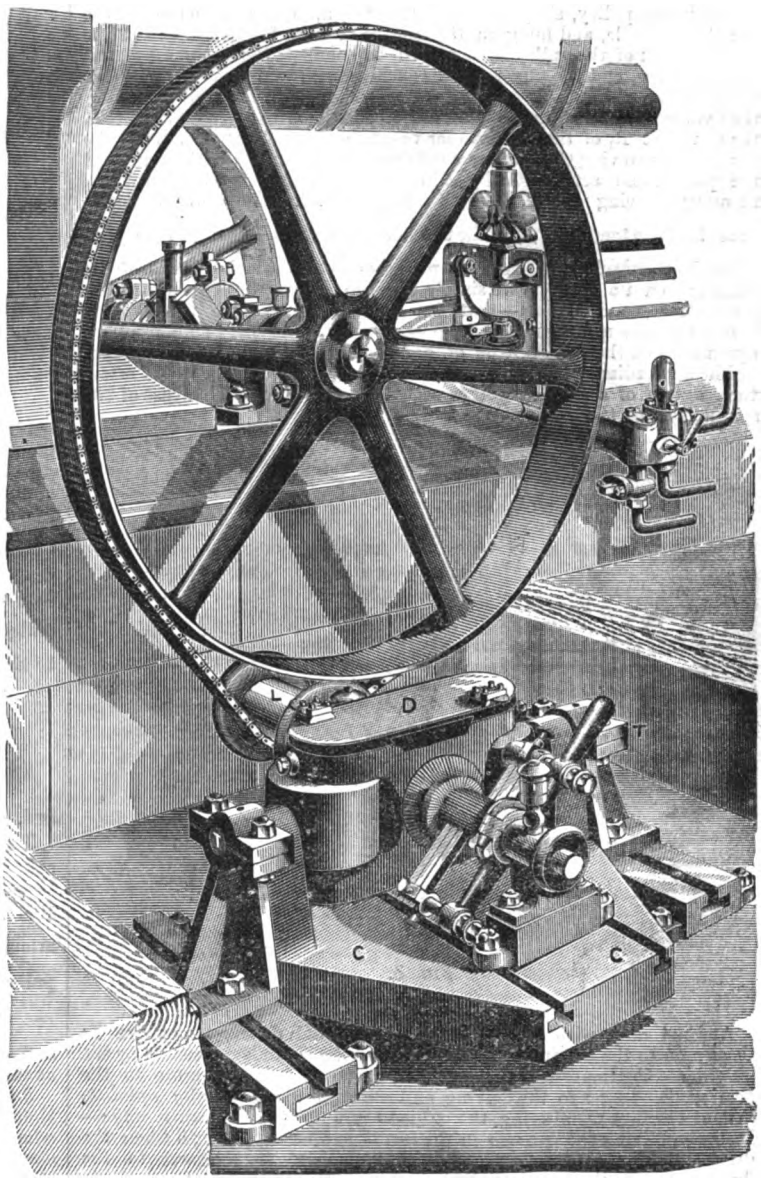

FIG. 2.

thrust on the bearings, and the power wasted in friction at the bearings cannot be made as small as is possible. And lastly, we are told by users of this form of gearing that there is a tendency for the whole framework supporting the dynamo to get into a state of vibration. The result is that this method is not one by means of which any dynamo can be arranged so as to be driven directly by the fly-wheel of any engine, and is only employed when the engine and dynamo are constructed so as to form practically one piece of machinery.

A form of gearing employed for driving a dynamo with a gas engine may be seen in the city, and at first sight this might appear to be merely the inversion of the gearing just described, because in this latter the pulley of the dynamo, instead of resting on the top of the engine fly-wheel, is pressed up against it below. But although this makes a less cumbersome arrangement, there is not any saving in the power wasted in friction at the bearings of the armature spindle, as there is in the Siemens gearing, since with the latter arrangement a force equal to the sum of the weight of the pulley and the force pressing the pulley up against the fly-

* Paper read before the Society of Telegraph-Engineers and Electricians, April 28, 1887.

† Since the writing of this paper we have learnt that this ingenious method of driving is due to Mr. Raworth.

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wheel has to be transmitted through the bearings. It is not, therefore, necessary to consider this form of gearing in detail, since it is not one that saves any portion of the waste of power in the friction at the bearings.

We now come to the new method which we wish to bring before you, and which consists in hanging the dynamo pulley L from a short belt passing round the engine fly-wheel F, as seen in Fig. 2, the belt being only just long enough to embrace the fly-wheel and dynamo pulley without the two being brought into contact. The dynamo D, as in the previous case, is supported so as to turn round an axis at right angles to the axis of rotation of the armature, and the method of fixing the dynamo is as follows :—The pulley is removed from the spindle S, and the dynamo is fixed in a cradle, C C, turning on trunnions, T T, in such a position that the dynamo and cradle just balance. Then, if p_1 p_2 be the pressures of the armature spindle on the two bearings B_1 B_1, respectively nearer to and further from the pulley end of the dynamo,

$$p_1 + p_2 = \text{weight of armature, commutator, and spindle.}$$

The pulley, which is heavier than an ordinary dynamo pulley, but, like an ordinary pulley, simply made of cast-iron, is now keyed on to the armature spindle, and hung in the belt, as seen in the figure, and as the entire weight of the pulley is supported by the belt, the dynamo by itself still balances, and the pressures on the bearings are simply p_1 and p_2, as before. The pulley L_1 is made of such a weight, and the cradle carrying the dynamo is placed in such a position relatively to the fly-wheel, that the resultant R_1 of the tensions for the two sides of the belt, when the dynamo is receiving the maximum driving power, is equal to the weight of the pulley, and acts vertically through its centre, together with the necessary driving couple, V V, as seen in Fig. 3. The horizontal components of the tensions P, Q in the two sides of the belt $\frac{A B}{B C}$ are in equilibrium by themselves, so that the pressures exerted by the spindle of the armature on its bearings are simply equal to the weight of the armature, commutator, and spindle—that is, are even less when the dynamo is receiving the maximum driving power than in the case of an ordinary dynamo when the armature is *at rest*, since our form of belt gearing, unlike any ordinary belt, communicates *simply a pure couple* to the armature, instead of a couple together with a smaller or greater thrust of the spindle against the bearings.

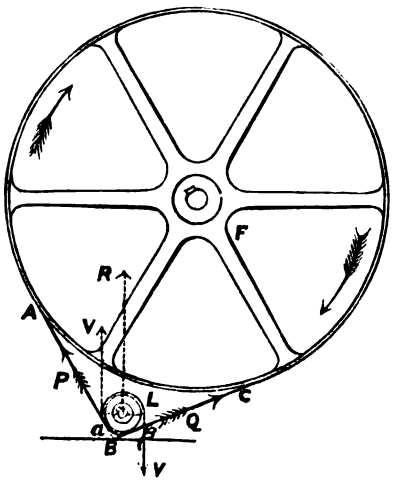

FIG. 3.

And not only with this mode of driving need no extra pressure be thrown on to the bearings, but the pressure that is produced merely by the weight of the armature can be diminished. In fact, the pressure on the bearing, B_1, nearer to the driving pulley *can be made actually equal to nought* by slightly altering the adjustments in the following way :—Instead of fixing the dynamo in the cradle so that it balances when the driving pulley is removed, fix the dynamo a little nearer to the fly-wheel, so that the pulley end of the dynamo is a little the heavier, and move the cradle C C a corresponding distance away from the fly-wheels, so that the pulley, when keyed on to the armature spindle, and the fly-wheel are properly in line. Then the tensions in the two sides of the belt are balanced, not merely by the weight of the pulley, but by this weight plus any portion, or the whole, of p_1 depending on the exact position in which the dynamo has been fixed on the cradle. Hence the weight of the pulley may be made smaller by an amount equal to the portion of the pressure p_1 which is carried by the belt, and the pressure on the bearing B_1 nearer the pulley, which, with an ordinary dynamo, is by far the larger, can, with this arrangement, be made as small as we like, or even nought, whether the armature be at rest or the dynamo be producing its maximum power. The pressure on the other bearing, B_2, will of course never exceed p_2, which is usually equal to about half the weight of the armature, commutator, and spindle. And, since the diameter of the spindle on the side farther away from the pulley can be made comparatively small, as power is not transmitted through it, the power spent in overcoming friction at this bearing, B_2, will be trifling. Hence the total waste of power at the bearings can be made practically nought by employing this form of belt gearing.

And further, this gearing has the following advantages not possessed by the Siemens gearing :—

1. There is no paper pulley to be constructed and to wear out.
2. The rim of the engine fly-wheel need not be specially turned up.
3. The axes of rotation of the armature and fly-wheel need not be accurately parallel, as the yielding of the belt allows for want of perfect parallelism.
4. The cradle of the dynamo is low down, and therefore can be made steady.

It is also clear that any slight stretching of the belt will not cause it to become slack, since the only effect will be to lower the pulley slightly, and incline the axis of the armature to the horizontal.

To further illustrate this method of belt gearing we give the actual calculations made for determining the proper weight to give to the dynamo pulley, and the proper position in which to place the dynamo, which is now being driven by a short belt at the central institution.

The four things to be determined are—

1. Proper size of dynamo pulley.
2. Proper weight of dynamo pulley.
3. Proper distance to place axis of armature below axis of fly-wheel.
4. Proper distance to place axis of armature to one side of axis of fly-wheel.

1. The dynamo in question requires about 6 horse-power when running at 1,600 revolutions per minute, and when giving out the safe maximum number of watts. The fly-wheel of the engine is 4ft. 11in. in diameter, and runs at 180 revolutions per minute; therefore, in order that the dynamo may be driven by a belt directly from the fly-wheel, the diameter of the dynamo pulley must be

$$\frac{180}{1600} \times 4' 11'', \text{ or } 6\tfrac{3}{4}\text{in.}$$

2. Let P and Q be the tensions, in pounds, of the belt on the tight and slack sides respectively, when the dynamo is receiving 6 horse-power, then

$$(P - Q) \times 1{,}600 \times \pi \times \frac{53}{8 \times 12} = 6 \times 33{,}000,$$

$$\text{or } P - Q = 71{\cdot}3, \text{ say } 72\text{lbs.}$$

If the rim of the dynamo pulley were in actual contact with the rim of the fly-wheel, it is easy to show that the angle between the belt on the two sides of the pulley would be 105deg. The pulley and fly-wheel must not touch, since they would be moving in opposite directions at the place of contact. But in order to make the arrangement compact it is desirable that the pulley should be as near the fly-wheel as it conveniently can be without touching; therefore let us take 100deg. as the angle that the belt shall make on the two sides of the pulley. Then, since the belt makes a tangent with the pulley, the arc of contact of the belt with the rim of the pulley must be 180deg. – 100deg.—that is 80 deg., or $\frac{4}{9}\pi$. Therefore, if P be the tension of the tight side of the belt, and Q that of the slack side,

$$\frac{P}{Q} = \epsilon^{0{\cdot}4 \times \frac{4}{9}\pi}$$

$$\therefore \quad P = (P - Q)\ \frac{\epsilon^{0{\cdot}1778\pi}}{\epsilon^{0{\cdot}1778\pi} - 1},$$

and, as just shown, P – Q equals 72lb.

Therefore $P = 169\text{lb.}$,

and $Q = 97\text{lb.}$

By the triangle of forces it is seen that the resultant of P and Q equals 180lb. Therefore, if the dynamo is so placed that half the weight of the armature and spindle, which is $\frac{94}{2}$lb., is borne by the belt as well as the pulley itself, the weight of the pulley must equal

$$180 - \frac{94}{2}, \text{ or } 133\text{lb.},$$

and a pulley of this weight was cast, and is at present in use on the dynamo at the Central Institution.

3 and 4. To determine the position in which the axis of the armature should be placed below and to one side of the axis of rotation of the fly-wheel, we have the condition that the horizontal components of the tensions on the two sides of the belt should be equal and opposite in order that there may be no side thrust. Hence, if α and β be the angles that the two sides of the belt make with the horizontal (Fig. 3),

$$P \cos \alpha = Q \cos \beta,$$

$$\text{or} \quad \frac{\cos \alpha}{\cos \beta} = \frac{Q}{P} = 0{\cdot}574.$$

And since the angle between the two sides of the belt is 100°,

$$\therefore \alpha + \beta + 100° = 180°,$$

$$\text{or} \quad \beta = 80° - \alpha,$$

$$\therefore \cos \alpha = 0{\cdot}574 \cos (80° - \alpha),$$

and expanding we have

$$\tan \alpha = \frac{1 - 0{\cdot}574 \cos 80°}{0{\cdot}574 \sin 80°} = 1{\cdot}59,$$

$$\therefore \quad \alpha = 57° 50',$$

$$\text{and} \quad \beta = 22° 10'.$$

Plotting these results to scale it is found that the distance of the centre of the dynamo pulley below the centre of the fly-wheel must be 2ft. 8½in.,

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and the distance sideways 10½in., a result which is also confirmed by calculation. And this is the position in which the dynamo was placed some six months ago.

As a proof of our conservative familiarity with the ordinary method of driving a dynamo, instead of with the principles of belt gearing, the first remark made by almost everyone who has seen the new gearing is that the belt must slip very much. As a matter of fact, however, so far from there being any serious slip, experiment shows that the dynamo, when giving out its maximum power, rotates a little faster than the calculation makes it, due of course to the diameters of the fly-wheel and pulley not being exactly as stated in the calculation.

We need not dwell here on the fact that ropes may be used instead of belts. Again, when a number of dynamos have to be driven from one fly-wheel in a confined space, one driving belt may be used for all, and, by means of guide pulleys, arranged so that each dynamo pulley lies on the belt between two guide pulleys, the part of the belt on one side of each dynamo-pulley being nearly horizontal and on the other side nearly vertical.

THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION, AND CAPACITY.

BY W. E. SUMPNER, B.SC.

(Continued from page 172.)

General Formula.

The following method of treating the general problem of a network of conductors will be found simpler in working than that of Clerk-Maxwell, who (Vol. I., sec. 280) expresses potentials in terms of the conductivities of the different branches:

Let E_x denote the E.M.F. in any branch x of the network.
" C_x " current " " "
" L_x " coefficient of self-induction in any branch x of the network.
" M_{xy} " coefficient of mutual induction between the branches x and y of the network.
" x " resistance of the branch x.
" F_{xy} " ratio of a definite electromotive force in the branch x to the steady current in the branch y produced by it. This ratio depends only on the resistances of the network branches.

Let the positive direction of any branch be defined as that direction in which an electromotive force must act in that branch to produce a current in a particular direction in a particular branch, and let the current or E.M.F. of a branch be considered positive when acting in the positive direction of the branch.

It follows, from Maxwell (Vol. I., sec. 281), that

$$R_{xy} = + R_{yx},$$

and also that the above definition is equivalent to the following:—

The positive direction of any branch is the direction of the current produced in it by a positive electromotive force in a *particular* branch.

The kinetic energy due to the mutual induction of the branches x and y is

$$M_{xy} C_x C_y.$$

If the electromotive forces in the network tend to increase either of the currents C_x or C_y there must be created an opposing electromotive force in the other branch, since otherwise energy would be created. From this it follows that

$$M_{xy} = + M_{yx}.$$

Since self-induction, mutual induction, and capacity supply extra electromotive forces while the currents are changing, we can at once write down an expression for the current passing through any particular branch g

$$C_g = \Sigma \frac{E_x}{R_{xg}} - \Sigma \frac{L_x}{R_{xg}} \frac{d C_x}{d t} - \Sigma \Sigma M_{xy} \left\{ \frac{1}{R_{xg}} \frac{d C_y}{d t} + \frac{1}{R_{yg}} \frac{d C_x}{d t} \right\} + \Sigma \frac{z^2 K_z}{R_{zg}} \frac{d C_z}{d t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where we suppose each condenser K_z to be shunted by a wire of resistance z and no self-induction. Under these circumstances it has been shown in an earlier part of the paper that the extra electromotive force due to this cause is

$$+ z^2 K_z \frac{d C_z}{d t} = + z \frac{d K_z V_z}{d t} = z \frac{d Q_z}{d t},$$

where V_z is the potential difference and Q_z the charge of the condenser z.

If, with Maxwell, we define the electro-kinetic momentum of the branch x to be

$$P_x = L_x C_x + \Sigma M_{xy} C_y,$$

we may write equation (1)

$$C_g = \Sigma \frac{E_x}{R_{xg}} - \Sigma \frac{1}{R_{xg}} \frac{d P_x}{d t} + \Sigma \frac{z}{R_{zg}} \frac{d Q_z}{d t} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In order to get the effect of a condenser whose terminals are merely connected to two points on the network, we shall have to consider the limit of $\frac{z}{R_{zg}}$ when z is made infinite.

We get, by integrating (2),

$$Q_g = Q_e - Q_p + Q_k \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where Q_g = total quantity which has passed through the galvanometer.

$$Q_e = \Sigma t \frac{E_x}{R_{xg}},$$

$$Q_p = \Sigma \frac{1}{R_{xg}} \{ (P_x)_t - (P_x)_o \},$$

$$Q_k = \Sigma \frac{z}{R_{zg}} \{ (Q_z)_t - (Q_z)_o \},$$

the suffixes t and o denoting the line of evaluation. If the currents proceed from one steady state to another, we can evaluate the effect of all condensers shunted by wires by diminishing the self-induction of each wire by Kz^2, K being the capacity of the condenser and z the resistance of the wire. In the case when z is infinite we must find the limit of $\frac{z}{R_{zg}}$.

Imagine the terminals of the condenser replaced by those of a battery, and let ρ be the ratio of the current through the galvanometer to that through the battery; then

$$\rho = \left[\frac{z}{R_{zg}} \right]_{z=\infty}$$

For imagine an electromotive force E to be located in the branch z. The ratio ρ is, by definition,

$$\frac{E}{R_{zg}} : \frac{E}{R_{zz}} = \frac{R_{zz}}{R_{zg}},$$

But $\frac{R_{zz}}{R_{zg}}$ is independent of z, as we show later (10); so that ρ is also

$$\left[\frac{R_{zz}}{R_{zg}} \right]_{z=\infty} = \left[\frac{z}{R_{zg}} \right]_{z=\infty}$$

because $R_{zz} = z + R_o$, where R_{oz} is the resistance of the network between the extremities of z, supposing z removed.

It follows $\frac{1}{\rho}$ = (coefficient of z in R_{zg}).

It is noteworthy that we may write equation (1)

$$C_g = \Sigma \frac{E_x}{R_{xg}} - \Sigma \frac{L'x}{R_{xg}} \frac{d C_x}{d t} + \Sigma \frac{z}{R_{zg}} \frac{d Q_z}{d t}, \quad (4)$$

where

$$L'x = L_x + \Sigma \frac{R_{xg}}{R_{yg}} M_{xy};$$

so that the total effect on the galvanometer will be exactly as if the self-induction of every branch x were increased from L_x to $L'x$, as above defined, and the mutual induction removed.

Equation (3) shows that for a complete cycle Q_p and Q_k will be each zero, provided the resistances of the bridge are not changed. If, however, as in an Ayrton and Perry's cycle, some of the resistances are changed, the cycle must be divided into parts during which no such change takes place, and the integrals for each part must be added. In such cases the self-induction of the galvanometer will probably produce an effect, and must be allowed for.

Thus Mr. H. B. Bourne, while experimenting at the Central Institution on the apparent resistance of a periodic make-and-break placed in one of the arms of the bridge, found that by adding self-induction to the galvanometer branch the result was considerably affected.

The definition given above of the positive direction of a branch serves our present purpose. It is, however, faulty in so far that a positive electromotive force in any branch does not necessarily produce positive currents in *all* the other branches. The ambiguity arises from the fact that the network functions R_{xy} are constrained by definition to be essentially positive quantities.

General Network of Conductors.

The most general case of a network of conductors is that in which p points are connected by branches in such a way that each point is the junction of three branches, and of three branches only. Any other network can be deduced from this by diminishing to zero the resistances of one or more of the branches. In the general case p must be even, since the number of branches is $\frac{3}{2} p$. Let $p = 2n$, and call n the degree of the network. If we increase to infinity the resistance of any branch, we merely diminish the degree of the network by unity.

There will be $3n$ branches, $3n$ currents, $\frac{3n(3n-1)}{2}$ network functions of the form R_{xy}, and $3n$ more of the form R_{xx}. There are only $(n+1)$ independent currents, since at each of the points of the network we have an equation of continuity, and $2n-1$ of these are independent.

Moreover, for each point of the network we have three equations of continuity for the network functions—

$$\left.\begin{aligned} \frac{1}{R_{xx}} &= \frac{1}{R_{xy}} + \frac{1}{R_{xz}} \\ \frac{1}{R_{yy}} &= \frac{1}{R_{yz}} + \frac{1}{R_{yx}} \\ \frac{1}{R_{zz}} &= \frac{1}{R_{zx}} + \frac{1}{R_{zy}} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where the branches x, y, z meet in a point. We shall get $(n+1)$ independent equations connecting the electromotive forces, the currents, and the resistances of the different branches. These equations will be linear for either currents or resistances. By solving for any current C_x we shall get

$$\Delta C_x = \Sigma E_y \Delta_{yx},$$

where Δ is a determinant of the resistances of degree $(n+1)$ which will be the same for each of the independent currents, and which, in consequence

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of the simple sum and difference relation between these currents and the others, will be the same for all the currents. Δ_{yz} will be a first minor of Δ corresponding with the electromotive force E_y and the current x. Its degree is n. Suppose the only electromotive force is that in the branch y, then, from definition,

$$R_{xy} = \frac{\Delta}{\Delta_{yx}}.$$

Now Δ must consist of products formed by taking combinations of $(n+1)$ of the resistances. It can only consist of positive terms; for, from simple physical considerations, $R_{xx} = x + R_{ox}$, where R_{ox} is the resistance of the network between the extremities of the branch x, supposing x removed. R_{ox} must be positive, and is independent of x;

whence
$$R_{xx} = \frac{\Delta}{\text{coefficient of } x \text{ in } \Delta} = \frac{\Delta}{\Delta_{xx}} \quad . \quad . \quad . \quad . \quad . \quad (6).$$

The sign of Δ must therefore be the same as that of the coefficient of x. But x is any resistance of the network, therefore each term of Δ must have the same sign.

This argument also proves that Δ can contain no power of x higher than the first, for otherwise R_{ox} would involve x. Hence Δ consists of products of different combinations of $(n+1)$ resistances of the network, and consists of only positive terms. It does not involve all the combinations possible, because, although involving all the resistances, and although the same for each current, it has not been formed in a symmetrical fashion. It has been obtained by considering $(n+1)$ branches, no three of which meet in a point.

In the expression for Δ we must therefore exclude those combinations involving the product of the resistances of any three branches meeting in a point.

Δ consists of the sum of the products of the resistances of all combinations of $n+1$ branches which are such that independent currents may be supposed to exist in them . . . . . (7).

If we diminish to zero the resistance of any one branch of the network, Δ will be diminished by the sum of the products containing this resistance as a factor. We cannot introduce new products by this means.

Now let $a\ b\ c\ \ldots\ x$ be any $(n+1)$ branches of the network, and suppose we diminish the resistances of the remaining $(2n-1)$ branches till they are infinitely small. It will still be true that

$$R_{xx} = \frac{\Delta}{\text{coefficient of } x \text{ in } \Delta},$$

where x is any one of the $(n+1)$ branches chosen.

Now Δ will be infinitely small unless it contains as one of its terms the product $a\ b\ c\ \ldots\ x$, since any other product of $n+1$ resistances will contain at least one infinitely small resistance as a factor. If Δ does contain this product we shall have

$$R_{xx} = x + \text{terms infinitely small.}$$

Proceeding to the limit, we have

$$R_{xx} = x,$$

which means that the branch x has been short-circuited by making the $2n-1$ resistances zero.

Δ can therefore only consist of the sum of such products of $(n+1)$ resistances that the branches with which they correspond are each short-circuited by making the remaining $(2n-1)$ resistances zero. It must contain every such product, for if the remaining $(2n-1)$ resistances are zero we must have for each of the $(n+1)$ resistances

$$x = R_{xx} = \frac{\Delta}{\text{coefficient of } x \text{ in } \Delta},$$

which shows that Δ must reduce to and contain the product $a\ b\ c\ \ldots\ x$.

(To be continued.)

THE RELATION BETWEEN THE CROSS SECTION OF THE IRON IN ARMATURE AND FIELD OF THE GRAMME DYNAMO.*

By Mr. Dugald Jackson, of Cornell University.

The relation between the cross section of iron in the armature core to that in the magnet limbs in a dynamo machine is an important one. On its proper adjustment, in an otherwise well-designed machine, depends the attainment of maximum efficient output per pound of wire with minimum of iron. Of two machines designed for a given purpose, the one with a Siemens armature and the other with a Gramme ring, the path of the lines of force through the armature of the latter machine will usually be considerably longer than in that of the other. It is evident that special care should be exercised to make the Gramme armature of sufficient area of cross section that its magnetic resistance be not increased unduly. Siemens armatures from mechanical principles call for a goodly amount of iron, while an increase of cross section in a Gramme armature increases mechanical difficulties considerably. Consequently Gramme armatures usually have considerably smaller cross section than Siemens armatures in machines intended for a similar use, magnetic conductivity being sacrificed for mechanical convenience in the Gramme. How far this sacrifice may be carried without impairing the value of the machine must of necessity be specially determined for each individual case.

The question of how far the characteristic, and so the output of a machine, is influenced by variations in the cross section of the armature could be determined by Hopkinson's very beautiful method of predetermining characteristics. In a machine, the outline and dimensions of which are determined by conditions imposed, the curves of magnetisation, such as Dr. Hopkinson used, would be fixed for the field and air space. By plotting curves for armatures of various cross section, the area giving the best characteristic, and yet not unduly decreasing the internal diameter of the ring, would be evident. The value of the leakage ratio n might be estimated by Prof. George Forbes' method, if the shape of the diagrams were not too complicated.

An experimental solution of the problem for a little dynamo was made this term in the Physical Laboratory at Cornell University. If we had armatures for one dynamo made with cores of various cross-sections, the best section would be apparent from the characteristics. However, it is not necessary to wind the armatures, but simply to measure the number of lines of force passing through the armature for various magnetising forces—that is, observing the data for a curve of magnetisation. This may be done in several ways.

In the experiment referred to, a single turn of wire was placed around the section of the armature core perpendicular to the direction of the lines of force. This was connected with a ballistic galvanometer. The swing of the needle of the galvanometer was observed when the current was reversed in the magnetising coils on the field. The swing was thus proportional to 2 H A, A being the area of the turn of wire, and H the induction per unit area. Knowing the magnetising current and the corresponding swing for a number of points for each of several different armatures, the corresponding curve of magnetisation may be plotted. These curves are exactly similar to the total characteristic of a series dynamo or the internal characteristic of a shunt machine.

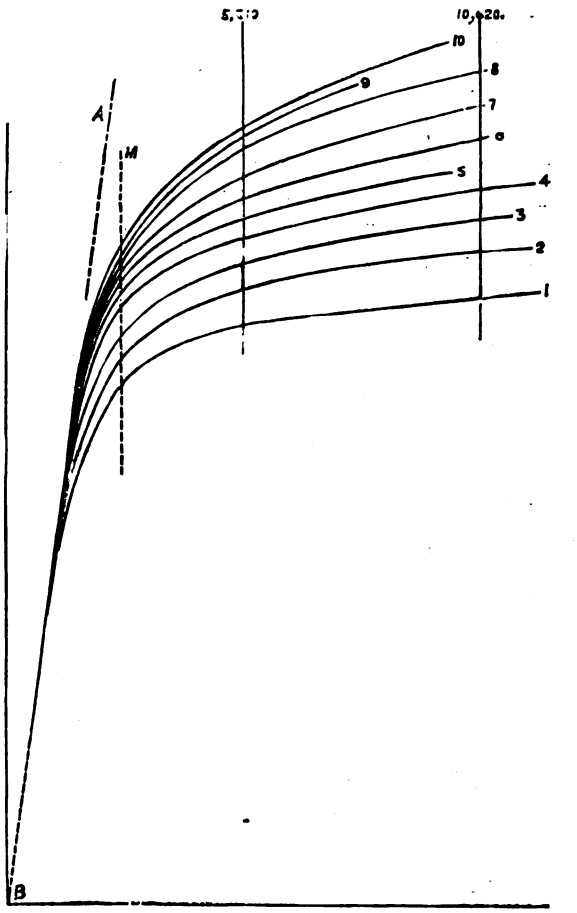

Fig. 1.

The field of the little dynamo experimented upon is of the single horse-shoe type standing upon the yoke. This is rectangular in cross section. The limbs are cylindrical and are held in place on the yoke with two pins each, the contact surfaces being perfectly plane. The yoke and limbs are of the best Norway iron. The pole-pieces are of a very good quality of cast iron, and are chambered to fit the upper ends of the limbs, which enter for a length of 7 cm., making the area of contact considerably greater than the cross section of the limbs. The cross section of the pole-pieces is much greater than that of the limbs. The bore of the pole-pieces is 10·8 cm. in diameter, there being a gap at the top and bottom subtending an angle at the centre of the bore of 51 degrees. The width of the surfaces on either side of the gap is ·3 cm. The corners of the pole-pieces are all rounded off.

Following are the dimensions:

Limbs (cylindrical)—

Length	20·3 cm.
Diameter	6·35 ,,
Area of cross section	31·66 sq. cm.
Distance apart from centre to centre	17·9 cm.

* Paper read before the American Institute of Electrical Engineers.

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Yoke (rectangular)—

Length	26·8 cm.
Width	8 2 ,,
Depth	6·9 ,,
Area of cross section	56·6 sq. cm.

Pole-pieces—

Height	10·2 cm.
Width	10·2 ,,
Bore	10 8 ,,
Mean area of cross section	— sq. cm.

The magnetising coils consist of 785 turns on each limb, making a total of 1,570 turns.

The armatures were composed of thin punched discs of soft wrought iron obtained through the courtesy of T. Pray, jun., of Hartford, Conn. The discs were insulated by dipping them into shellac varnish and then built into armatures by placing them on wooden mandrels turned to fit their internal diameter. The variation in the cross section of the armatures was obtained chiefly by using armatures of the same number of discs, but of different internal diameters. As it was not possible to secure discs with the proper internal diameters to give all the area desired, some of the armatures were composed of fewer discs. In these, thin spaces were left between the discs, and the area enclosed by the exploring coil was slightly greater than that of the iron. The effect of this has been neglected as too small to be appreciable. The areas were obtained by multiplying the thickness of the discs, which was ·0462 cm., by the number on the armature.

The magnetising current was furnished by a number of storage cells. In the circuit of these were placed a tangent galvanometer and the magnetising coils. A reversing key was so placed in the circuit as to simultaneously reverse the current in the galvanometer and coils. The magnetic induction was measured by a ballistic galvanometer, as already explained. The observations were taken by Mr. F. R. Jones, an engineering student working in the laboratory. The regularity of the curves attests the care with which he carried out the work. I have here a sketch (Fig. 1) of the curves determined by Mr. Jones, which, I think you will agree with me, are very interesting.

The following table gives the areas of the cross section of the armatures and their ratios to the cross section of the magnet limbs :—

Armature No.	1	.....	17·75	Cm.	.....	Ratio	.....	0·561
,, ,,	2	.....	19 23	,,	.....	,,	.....	0·607
,, ,,	3	.....	20·70	,,	.....	,,	.....	0·654
,, ,,	4	.....	22·19	,,	.....	,,	.....	0·701
,, ,,	5	.....	23 66	,,	.....	,,	.....	0·747
,, ,,	6	.....	25·14	,,	.....	,,	.....	0 794
,, ,,	7	.....	27·36	,,	.....	,,	.....	0·864
,, ,,	8	.....	29·18	,,	.....	,,	.....	0·922
,, ,,	9	.....	34·49	,,	.....	,,	.....	1·09
,, ,,	10	.....	42·44	,,	.....	,,	.....	1·34

In curve No. 1, where the armature has little more than half the area of the limb, the turn in the characteristic is sharp, and the straight line representing the upper portion of the curve is almost horizontal. The rapid and great increase of magnetic resistance shown by the curve to the right of the line M must be due entirely to the saturisation of the armature. As the area of the armature increases, the turn in the corresponding characteristics grows into a longer sweep, and the upper part of the curve takes an increasing angle with the horizontal. Curves Nos. 9 and 10 are given by armatures greater in cross section than the limb, and though there is a difference in their areas equal to a quarter of the area of the limbs, there is very little difference in the total induction passing through the armature. The curve No. 10, then, probably very nearly represents the curve of magnetisation of the iron in the field and the air space. The straight line, which constitutes the lower part of the characteristic, being the backbone of the curve, as it were, must very nearly represent the line of magnetic resistance of the air space. By air space I mean the space between the pole-piece and armature.

Looking at the curves there, you see the armature No. 1 was highly saturated, or, in other words, had become of enormous magnetic resistance before the permeability of the field began to decrease appreciably. On the other hand, armature No. 9 has increased in magnetic resistance very little up to the point to which the characteristic has been carried, while the field is quite saturated. Between these extremes there are varying degrees of relative saturisation of the armature. In curve No. 7, the field and armature are apparently at about equal degrees of saturisation throughout. The curve (shown in Fig. 2) illustrates the effect on the total induction through the armature of the ratio of the area of the armature to that of the limbs. As ordinates are plotted total induction through the armatures taken from the characteristics on the section line M. The abscissæ are ratios of the cross-section of the armature to that of the limbs.

This curve is exaggerated in vertical scale so that its character may be more plainly seen. It shows obviously that the induction through the armature increased quite rapidly when the armature core was increased in area from ·5 of that of the magnet limbs to about ·75 of that of the limbs. From ·75 to ·9 there is still an increase of induction with increase of armature core, though not so good as before, and beyond ·9 the increase is of no practical importance.

If the section at M, Fig. 1, had been taken farther up the curves, the relative increase of total induction with increase in the area of the larger armature would not have been so marked.

The section at M is taken at 2,660 ampere turns ; that is, an absolute magnetising force of 33,420. The absolute total inductions for this magneto-motive force are shown in the curve, Fig. 2. These were determined by comparing the throw of the ballistic galvanometer given by the armature with that given by a standard coil turned through 180 degrees in the horizontal component of the earth's field. The value of the horizontal component at the place of the standard coil was determined by comparison with that in our magnetic observatory by the use of the compensated magnetometer.

We may safely assume that the cross section of the armature should be about ·75 of the cross section of the limbs if the wire on the armature is to have the greatest activity without an excessive quantity of iron in the core. By making the cross section of the armature ·6 of that of the limbs, a loss of 10 per cent. of the total induction, when the ratio is ·75, would be made, and consequently an equal loss in E.M.F. and the output of the machine. This is a case where the permeability of the field-magnet is equal, or very nearly equal, to that of the armature. If the permeability of the armature core were greater than that of the field the area of armature could be a smaller ratio.

No allowance has been made in this for the effect of a current in the armature. That should at any rate be small, except in the case of arc lighting machines, where a great number of turns of wire are placed on the armature with the purpose of gaining stability in the lights.

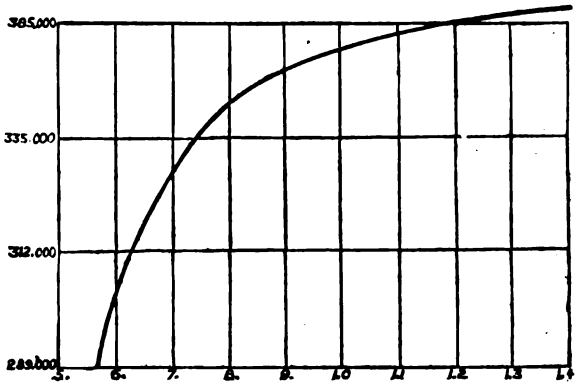

FIG. 2.

The absolute intensity of the magnetic flow per square cm. in the armature was quite high. In armature No. 5, the section of which is practically ·75 that of the limbs, an induction of 14,000 per square cm. was given by 2,666 ampere turns. For about 10,000 ampere turns the induction was 17,000 per square cm. 10,000 ampere turns gave an induction of 11,000 per square cm. through armature No. 10, and about 18,000 in armature No. 1. The latter was increased to nearly 19,000 by 12,500 ampere turns.

The induction per square cm. corresponding to the best conditions in this machine is 14,000 per square cm. This is high for a dynamo. I believe Dr. Hopkinson has placed the figure in the Edison-Hopkinson machine as 8,000, and, if true, this is probably seldom exceeded. I am aware that the value apparently reached 20,000 in the Manchester dynamo in Hopkinson's late tests, but that high value cannot be given much weight, even though the armature was pretty well saturated. I may be placing the limit entirely too low, as I have a number of records where from 10,000 to 15,000 is claimed, but simple claims are endowed with great uncertainty.

It may be interesting to note the ratio of the areas in two or three dynamos of ordinary size. It is impossible to estimate the area of iron in an armature with wire on it, because of the uncertainty in the space occupied by insulating material between the iron discs. In the record of their late tests the Hopkinsons have given the areas of the armature and magnet limbs in the Edison-Hopkinson and the Manchester dynamos. In the Edison-Hopkinson machine the field had probably nearly the same permeability as that of the armature core. The cross section of the armature was about ·8 that of the field, and the field was considerably more saturated than the armature. In the Manchester dynamo the field probably had a lower permeability than the armature, and they were about equally saturated. The cross-section of the Gramme ring in this machine was about ·6 that of the cross-section of the field.

COMPANIES' MEETINGS.

United Telephone Company (Limited).

The seventh annual ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on the 5th inst., under the presidency of Mr. James Brand.

The SECRETARY (Mr. Thomas Blaikie) read the notice convening the meeting.

The CHAIRMAN then said : Gentlemen, I will commence the few remarks I have to make with one or two references to the accounts. You have all had a report, and I trust you will consider it sufficiently clear to speak for itself; but there are one or two points I will allude to. The capital expenditure this year has been £41,500; of this sum £36,000 has been

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used for the development of the metropolitan system, and £5,000 has been spent for telephones in use in our subsidiary companies distributed all over the country. Then, as to our revenue and expenditure, our metropolitan system, which, as you are aware, is now entirely separated from the rest of our business, shows an income of close on £90,000, being an increase of about £8,000 over the previous year. This is a substantial figure, but would have been disappointing to us did we not know that our progress had been retarded by the snowstorm in December last. To earn this increase we have spent about £2,000 less in working expenses. In addition to our expenditure for working expenses, we have spent £11,000 in repairs and replacements and by the damage through the snowstorm, and have put about £5,000 to suspense account for liabilities which are possible to turn up. Our reserve fund is now over £102,000 by the addition of over £4,000 from exceptional sources, and £1,200 has been set aside for depreciation of instruments in use all over the country. As to the dividend, the amount available for the whole year is £62,236. Of this you have received an interim dividend at the rate of 10 per cent., and we now propose to make this up to 13 per cent. for the year by a further payment of £35,804, and to carry forward to next year £4,053. The comparative statement we have placed at the end of the accounts will enable you to compare easily each year since the formation of the Company. You will notice that our metropolitan system is now debited with £11,000 for royalties, the same as if it had been worked as one of the subsidiary companies. It is now, however, divided into ten separate sections, each section having an efficient staff to develop, canvass, and work it. This division has for the moment caused some extra expenditure, as we have hired extra stores, &c., in most of the districts, so that all materials may be at hand for whatever work there is to do. But our extra expenditure will be more than repaid by greater efficiency. By this time next year we shall have 14 divisions, and the carrying out of the work for forming these divisions and working is even more difficult and intricate than the opening up of telephonic systems in the same number of separate towns. Then, as to switch-boards and the general working of the system; when I last had the pleasure of speaking to you I told you that we were completing the renewal of our two largest exchanges and one central trunk exchange with the most perfect switch-boards in existence, and that shortly we hoped to show our subscribers a much improved working. Well, in October last we had got our exchanges into a high state of efficiency, and our calls at the end of December had reached the high figure of 42,000 in one day, or equal to 84,000 telegrams. We were congratulating ourselves, and beginning to feel that our subscribers were well pleased, when the great snowstorm took place—you will recollect it was on Boxing Night—and in a few hours upset the labour of the whole year. This snowstorm hit us in two ways. It not only upset our system, which was working so well, but prevented us for nearly four months canvassing for new subscribers, and stopped all our plans for further development which we were preparing to carry out during the spring months; and it was necessary to devote the whole of our energy to putting our old subscribers once more in connection, rather than try to get fresh customers, which we knew could not be joined up. A good deal of annoyance was expressed and vexation caused by the apparent long delay that occurred in the replacement of our system. Many people thought that our work could have been done quicker, and ought to have been done quicker. But I can assure you that we did everything that seemed possible to us, and used every good man that was available at the time. You must remember that we did not stand alone in our misfortune. The storm was general all over the country, and every great railway as well as our subsidiary companies were suffering, and it was impossible to get trustworthy and skilled men at a moment's notice to fulfil the great demand for this special labour that had arisen. We did our best to overcome our troubles, and I believe we have succeeded fairly well. Our calls have again reached the position they were in when the disaster occurred. While we suffered much from this snowstorm, I trust we have gained somewhat by the lessons we have learned. We have secured the services of a very efficient consulting engineer, Mr. John Tomlinson, who has superintended the replacement of our wires, poles, and derricks. We hope we have found out our weak points, and have mended them in such a way that we are advised will minimise the effects of any future trouble. We should be glad, of course, if we could so arrange our wires as to avoid any further mishap; but the state of the law forces us to do work in one way that we would often like to do in another. If the recommendation of the Committee of the House of Commons of 1885 could be carried out to even a modified extent, we could overcome many of our difficulties without the least prejudice to the public, and certainly all danger from a breakdown of our wires would be done away with if we were allowed to run them in a straight line along the streets at right angles. This would avoid all the necessity of long spans, which is our principal weak point. I am glad to tell you that no accident whatever occurred to the public during all the time of the snowstorm. I may tell you that the telephone enterprise of Great Britain now comprises 212 exchanges, 19,000 subscribers and 225,000 messages per day average, with a gross income of £325,000 and about 30,000 miles of wire. Very little money has been spent by us in law, and there has been no litigation of any consequence in regard to the patents, since the decision of the Court of Appeal in favour of the Company in the action against Messrs. Bassano and Slater, of Derby, about twelve months ago. There was talk of an appeal in that case by the defendants to the House of Lords, but the time for notice has expired and no notice of appeal has been given. As might have been expected, a good deal of ingenuity has been exercised in attempts to construct good working telephones which do not come within the scope of the Company's patents, and if the paragraphs which appear from time to time in the newspapers are to be believed, these gentlemen are doing great things. But, singularly enough, they seem never to get beyond newspaper paragraphs. As soon as they make a decent instrument they seem to come within the Company's patents, and when they keep outside them they make instruments of no real commercial utility. We will not fail to maintain in the future, as in the past, the valuable patent rights secured by so much labour and expense, but we think we are best protecting our property by allowing many of these ingenious efforts to fail by their own weakness rather than by bringing the formidable and expensive artillery of the law to bear upon them in every case. That, gentlemen, I think is all I have got to say to you. I shall, however, be glad to answer any questions, or hear any suggestion that any shareholder has to offer before I put the resolution that the report and accounts be adopted.

The DEPUTY-CHAIRMAN (Mr. J. Staats Forbes), in seconding the motion, called special attention to the fact that the large sum of £15,777 had been charged boldly against the revenue of the year to meet the costs of the damage sustained by the Company through the severe snowstorm last December. That exceptional expenditure might fairly have been spread over a period, but it had been at once dealt with, and still they were able to pay the same dividend. He could not refrain from referring to the services which the Chairman, at great personal risk, rendered the day following the disaster; and the Managing Director, and, indeed, the staff generally, also deserved the warm thanks of the shareholders.

Mr. S. J. BUTCHER asked whether the Directors had considered the policy of having underground wires for, at least, the trunk lines. He thought that with underground lines they would be less liable to interruptions, the fear of which deterred new subscribers from joining.

Mr. WILLIAM ABBOTT said he was quite ready to admit that the Directors had had a very bad time during the snowstorm, but he must also not shut out from his mind that they were likely to have snowstorms again. He was greatly pleased to hear that they had called to their aid an efficient engineer. He thought that the Directors ought to have found out before the weak places in the system, but now that they were beginning to do so he had no doubt that they would discover a remedy. He must call into question one of the Chairman's statements—that the working of the telephone was giving perfect satisfaction at the time of the snowstorm. As one of the earliest subscribers he could say that that certainly was not the case. A large number of shareholders present were subscribers, and they had had a great deal to complain of with respect to the working of the Company's system. He certainly had no desire to throw cold water on the undertaking. On the contrary, he believed they were in possession of a veritable gold mine, second only to the telegraph itself; but he wanted the Directors to understand that what the shareholders expected was that the Board would leave nothing undone in order to secure rapid progress being made in the lifetime of the present subscribers. The Chairman had spoken of the comparative statement given at the foot of the accounts. Well, he (Mr. Abbott) observed from that that they had made the smallest amount of progress last year in the gross receipts than in any year since the Company was established. They could blame the snowstorm for a great deal of loss of net revenue, but they could not blame the snowstorm for the great loss of progress in the gross revenue. The gross revenue from the metropolitan system was £95,655 in 1886, and for the present year it had been only £100,899. What did that mean? Was it because they had not made any special effort to increase the number of the subscribers so long as this system was in a state of disorganisation? If so, that was an answer to his criticism. There was a feeling out of doors that there was a want of vigour shown in the administration of the Company's affairs. One of the things said to support that was that nothing had been done by the Company to extend its usefulness outside of London. He knew that on the Continent they had established a trunk line between Paris and Brussels, and he believed that that was doing remarkably well. Why should they in that Company not do something of the same kind? Was there any bar to their making a connection between the subscribers in London and Manchester and Liverpool? If so he wished the Chairman to let the shareholders know it; but, interested as the Company so largely was in the subsidiary companies, the sooner that the subscribers in London and the country had full advantage of conversation through the telephone the better for both of them. Last July he made a very daring proposal to the Chairman, to the effect that some effort should be made to separate the shares of the subsidiary companies held by them, and that they should be placed in a trust and distributed among the shareholders, the control of those companies being still vested in the Board. The Chairman told him on that occasion that they would think over the matter, and he (Mr. Abbott) would like to know to what extent their thoughts on the subject had carried them. Was there anything objectionable in his suggestion, or did they see their way to carrying it out? If not in the shape he had suggested, perhaps the financial genius on the Board, which he was pleased to acknowledge, could propound some other scheme, by which the shareholders might receive in the form of a bonus the very large amount of dormant capital held by them in other companies, and from which the Company derived a certain amount of revenue. He thought they were all agreed that they had a great and valuable property.

Mr. HENRIQUES said that a most important matter in the report was the reference to the snowstorm, and having such an efficient Board he thought they would do well to turn their serious attention to the strengthening of the supports which carried the wires. He had been in New York and had seen much more serious snowstorms than anything that was seen in this country, but he had not seen anything of the fall of wires such as had been the case here. He was an engineer, and knew something about what he said; and he said that anyone with ordinary knowledge would not have put up such weak supports to carry such wires as theirs and of such great weight. With a small expenditure the supports could have been strengthened, and thus, in his opinion, much of the loss they had sustained could have been avoided. He desired to know why, in the general revenue account, it cost nearly £8,000 to collect a sum of £43,000, which was the net revenue. He supposed that they took away from that the depreciation of instruments, but even then it was an enormous percentage to

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charge the accounts with in order to secure £43,000 out of £51,000. Coming on to the Metropolitan District account, it seemed to him that the Directors received the lion's share of the whole business. The salaries and wages amounted to £5,986, while the salaries of the Directors came to £5,298—in other words they got as much as the crowds of workmen who must necessarily be employed to do all the work. He considered that the enormous profits earned by the Company ought to go in a larger proportion to the shareholders.

Dr. BROWN said he had been greatly struck with the long lengths of wire crossing the streets, and they were dangerous owing to the want of solidity in the houses on which the supports stood. Every care ought to be used to fasten them so that snowstorms should not affect them.

Sir J. GOLDSMID, M.P., said he was chairman of a company which had a capital of £4,000,000, and the Directors were paid £5,000 a year. That was a very large business, and involved enormous attention on the part of the Directors. He saw that in the case of this Company the capital was £500,000, and the Directors had received £5,300 for the year. He knew that the system of paying directors by commission was the French system, and that it was adopted in many companies; but it was a bad system, and he regretted to see it introduced in London companies. He held that it was the duty of the Directors to reconsider the Articles of Association, and fix a large and liberal salary for themselves, not exceeding a fair amount, which ought to be paid to them for their services. By the present arrangement if the business increased as it ought to the Directors would receive a great deal more than they did already. He had heard the opinion expressed freely that the Directors had not done enough to extend the benefits of the system to the suburbs. He desired to state that his remarks had been made in no spirit of hostility to the Board.

The CHAIRMAN said he would inform the shareholders of how the present system of remunerating the Directors began. He did not think that the amount of capital of a company was anything to do with the question of the remuneration which the Directors should receive. When their Company began it had no capital at all, and it had been made by the efforts of himself and a few others who had been very devoted to the thing. It was much more difficult to manage at the outset when it had no capital than it was now. He wished to state for himself that he had not been paid half as much by the Company as he could have earned at any other business, and the amount he now received from the Company was not large, considering the work he had done, and which he had to do every day. Had Sir Julian Goldsmid spoken to him on the subject before the meeting he believed he could have shown that gentlemen that the Directors were not paid more than they deserved. He did not think it was a bad system to pay directors by commission. He had devoted himself for three years before the thing was got in order, and he received not a shilling all that time for what he did. Then he staked a good deal of money in the concern, and now that it was beginning to do well the Directors were getting a fair proportion; but he did not think that £5,000 was a very large sum for them to receive out of the profits considering the peculiar nature of the work. With regard to the extension of the benefits of the telephone to the suburbs, he knew it was a difficult matter to give satisfaction, but there were great obstacles in connection with extension to the suburbs. When by persistence they had forced lines out to different places they could not get the subscribers. He had got a line established at Tooting, with a call room there and at Clapham, but they were waiting for way-leaves—a question which was even more difficult in the suburbs than in London. The more they looked into these matters the more he was sure they would agree in believing that the Directors had done their best. Dr. Brown had referred to the length of the wires across the streets. That was so, but they could not help themselves in the matter.

Dr. BROWN: We want the Government to help us.

The CHAIRMAN, continuing, said that there was a recommendation by a committee of the House of Commons in 1885, but there had been so many great questions before Parliament and the Government that the telephone had been rather neglected of late, and it was not well for the Company to be always stirring in the matter. Mr. Henriques had spoken of the damage done by the snowstorm, but there had not been so many supports that had broken down. They were not allowed always to go on the best of roofs, and they could not re-roof old and rotten houses. They were obliged to put their poles where they could get the way-leaves. A great many of the way-leaves were on public houses, a great many of which in outlying places were roofed with tiles. Then Mr. Henriques had said that the supports were weak because they were overloaded; but they were overloaded because they could not get more roofs to put their supports on. They were daily doing all they could in regard to these matters, but they could not go where they liked, and they could not have as many poles as they liked, for which reason they were very often obliged to put on more wires than they would otherwise like to do. They did not pay £8,000 to collect the revenue. There were a variety of things included in the amount mentioned. There was the enormous work of the establishments, advertising, rent (which alone was £1,600), depreciation of instruments, &c. Then, Mr. Henriques said that the workmen ought to receive more.

Mr. HENRIQUES: No, I said that the Directors ought to receive less.

The CHAIRMAN: Ah, well I think you are wrong there [laughter]. Speaking for myself, I am sure you are wrong.

Sir J. GOLDSMID said he did not think that what he had said had been properly understood. What he had said was that the remuneration of the Directors, which he considered high now, would, by the Articles of Association, go on increasing with the increase in the revenue of the Company, and he had suggested that the Articles of Association should be reconsidered, with a view to putting the Directors' remuneration on a fair footing.

The CHAIRMAN said the Directors would be most happy to consider the suggestion. Mr. Abbott had spoken about the shares in the subsidiary companies, and he had told that gentleman on a former occasion that if he could show them a plan which would make the shares of the Company more valuable in the market without taking away from their intrinsic value, they would be very glad to consider it. It might be very nice to divide the shares in the subsidiary companies, but if they did that there would be less value in their shares of the United Company, and they would lose the power they now possessed in the subsidiary companies by virtue of the number of shares held. Mr. Abbott had spoken about telephonic communication having been established between Brussels and Paris but he did not know whether they had in those cities as many difficulties to contend against as they had in London. The Directors had made all kinds of experiments, in connection with which they spent a great deal of money, and no doubt they would succeed ultimately. At present, however, he would be wrong if he told them that under existing circumstances, or circumstances that were likely to arise at present, they could get commercial telephonic intercourse between London and Manchester. He believed that if they could get a free line—free from telegraph wires and other matters of induction—they could get communication. They were doing what they could in the matter, and he hoped they would be able to give the shareholders a better account before their next meeting. They expected to be at Tilbury in two months, but it took a long time to put up these wires. Although it had been said that great satisfaction was not being given by the working of the system before the snowstorm, the Directors thought that the service had been greatly improved at the end of last year by the new switch-board, and he thought that that fact was evidenced by the statement he had made, that the calls had increased at that time to 42,000 a day. He was sorry that any dissatisfaction should have been expressed, but that would not prevent them from trying to improve matters. For four months after the storm they were making their old system good, and they could not very well develop new work while the old work was still undone. The patents would last four and a-half years from now. He thought that the danger of overhead wires looked greater than it was. They had never had an accident yet. He was not quite sure that they would obtain great efficiency by placing their wires underground, for even in the case of the telegraph a great deal of efficiency is missed.

A SHAREHOLDER inquired what the object of the reserve fund was, seeing that it was not applied to any great catastrophe such as occurred to them last winter.

The CHAIRMAN said that a great deal of the reserve fund was in the working of the Company—a fact which rendered it unnecessary for them to call up money and issue shares. The shareholders derived the benefit of the reserve fund in that way.

A SHAREHOLDER wished to know in what way the Directors would consider the suggestion of Sir Julian Goldsmid as to the question of their remuneration.

The CHAIRMAN said he could not state in what way they would consider the suggestion, which had only just been made.

A SHAREHOLDER: Supposing we could pay 20 per cent. next year?

The CHAIRMAN: Well, what a good thing for all of us!

Mr. E. DWYER GRAY, M.P., said he desired, as he was not present at the last meeting, when the shareholders did him the honour to elect him, to thank them for the confidence they had shown in him. There was always a certain delicacy in members of a Board defending their own salaries, but as the junior member of the Board, and as one who had had nothing to do with the hard work and tremendous exertions through which Mr. Brand and Mr. Forbes, and other members of the Board had gone, when the Company was in its infancy, and when most people regarded the telephone as a toy, he could approach the matter from an impartial standpoint. The effect of Sir Julian Goldsmid's proposal was this—that the gentlemen mentioned having made the Company a success should not be permitted to participate in its success on the lines to which the shareholders readily agreed before the success was accomplished. All the shareholders subscribed to the Company on the basis of the Articles of Association and the Memorandum of Association, which provided a certain method of remunerating the Board. Now, however, it was in effect suggested that they should turn round and say that the Directors had made the Company too successful, and that they ought not to be remunerated as they were entitled to by the original agreement. One gentleman had intimated that it would be a disastrous thing if a dividend of 20 per cent. could be paid next year, as in that case the Directors would receive so much more; but what would be the value of the shares and the position of the shareholders if 20 per cent. could be paid? He thought that they ought rather to pray that the Company might be able to pay 20 per cent than that they should look forward with any feeling of dismay to such a dividend. He contended, whether it was a general principle or not, that it was a sound commercial principle to pay directors by results. He was a member of the Committee of the House of Commons which investigated the question of overhead and underground wires. One shareholder had suggested that they ought to consider the propriety of trying to adopt the underground system. The evidence before that Committee, however, was clear—that the underground system was not as satisfactory for telephonic purposes as having the wires overhead, and that it was far more expensive. If the shareholders were serious in their desire that an effort should be made generally to adopt the underground system there would be no necessity to consider Sir Julian Goldsmid's suggestion, because the Company would have to provide £1,000,000 more capital, and reduce the dividend to 5 per cent., when the Directors would not be overpaid. That was what the result would be of adopting the underground system, which they might be driven to adopt, but which it would be very unwise for them to seek to establish in the teeth of the recommendations of the House of Commons Committee, who recommended that the Company should have increased facilities in regard to overhead wires. As to the lesser rate of progress in their gross revenue to which Mr. Abbott had referred, the new business had naturally ceased while the old business was dislocated; but new subscribers were coming

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in again, and they hoped next year to show a better state of things. The reduction of the net profit and the reduction of the rate of increase in the gross revenue were clearly traceable to the same cause—the severe snowstorm of last December. Though there might be snowstorms every year, the evidence before the Committee to which he had referred showed that such disastrous snowstorms as that of last December occurred in the metropolis about once in every ten years. As to what Mr. Henriques had said about severer snowstorms in New York, he would point out that there was a very great difference between one snowstorm and another. One storm might cover the ground feet deep and do no harm to telephone wires, and another stowstorm, where there was scarcely any snowfall, might do immense injury. In New York the atmosphere was dry, and snow fell in small particles, and did not accumulate on the wires, to which no harm was done; but when it fell almost in a melting condition, was then succeeded by a frost, followed by a thaw and another snowstorm, great injury was done to the wires. The question of extending telephonic communication to other towns was beset by great difficulty on account of the attitude of the Post Office towards the Company, and the difficulty of obtaining way-leaves. In view of the difficulties that had to be encountered it was a matter of astonishment to him that the telephone had made such progress in this country as it had.

Mr. BENSTEAD said if he could get a dividend of 25 per cent. he would be quite satisfied to give the Directors the extra remuneration that such a dividend would entitle them to. It had been rumoured that there would be a very great difference in their profits in the current year, owing to the abatement of the yearly fees paid by subscribers through their not having the full use of the telephone during the time the system was being put in repair after the great snowstorm last December.

The CHAIRMAN said that that had all been provided for, and they had put aside more money than they believed would be requisite to meet any contingency.

The motion was then adopted.

Mr. JAMES BRAND and Mr. J. S. FORBES were then re-elected to their seats at the Board.

On the motion for the reappointment of Mr. Joseph B. Morgan considerable discussion followed relative to the amount of fees paid to that gentleman, the value of whose services was generally recognised, and as to the possibility of the Company engaging the whole of his time, at an additional remuneration if necessary. It was pointed out that it was advantageous in the interests of the Company that Mr. Morgan should occasionally be out of London in connection with his position on the Boards of the subsidiary companies, as representing the Company. It was also stated by the Chairman that while they would be only too glad to have the whole of Mr. Morgan's services, that was not so necessary since the appointment of Mr. Tomlinson. Eventually Mr. Morgan was unanimously re-elected.

The retiring auditors, Messrs. Quilter, Welton and Co., and Messrs. Price, Waterhouse and Co. were re-elected.

On the motion of Mr. Abbott, a vote of thanks to the Chairman and Directors was passed, and the meeting then separated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 1st inst. amounted to £3,361.

CHELSEA ELECTRICITY SUPPLY COMPANY (LIMITED).—The annual return of this company, made up to the 15th of June, was filed on the 22nd ult. The nominal capital is £100,500, divided into 20,000 shares of £5 each, and 500 shares of £1 each. Only 150 of the £5 shares have been taken up; and the full amount has been called and paid thereon.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of June was 3,615, estimated to produce £2,750, against 3,377 messages, producing £2,767, in the corresponding month of last year. The traffic receipts for the month of March, estimated at £3,650, realised £3,727.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for June amounted to £1,563, against £1,522 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—The Eastern Telegraph Company give notice that the time for the exchange of the company's Four per Cent. Mortgage Debenture Stock, in place of the Five per Cent. Debentures, due 1st August, has been extended to July 16th.——The company announces that, subject to final audit, the accounts show, after placing £48,000 to reserve fund, a balance available for dividend sufficient to pay at the general meeting on 14th inst. the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the preference shares, and a final dividend of 2s. 6d. per share, with a bonus of 1s. per share free of income tax on the ordinary shares, making with previous payments on account a total dividend of 5½ per cent. on those shares for the year ended 31st March, 1887.——The traffic receipts of this company for June, 1887, amounted to £45,426, and to £45,100 in the corresponding period of 1886.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of June, 1887, amounted to £35,138, and to £38,894 in the corresponding period of 1886.

GREAT NORTHERN TELEGRAPH COMPANY.—The latest traffic returns of this company are as follows:—Receipts in June, 1887, £23,600; from 1st January to 30th June, 1887, £127,120; corresponding months of 1886, £124,560; ditto, 1885, £142,340.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended 30th June were £4,400.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 1st inst. were £2,540, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 30th June are £2,921, as compared with £2,881 in the corresponding period of 1886. The February receipts, estimated at £5,844, realised £5,852.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 6.		BUSINESS DONE WEEK ENDING JULY 6. Highest.		Lowest.	
Anglo-American	37½,	38½	38¼		36½	
Do. Preferred	60,	61	60½		58⅝	
Do. Deferred	14½,	15½	15⅝		14⅜	
Brazilian Submarine	11,	11½	11⅝		11	xd
Cuba	12,	12½	—		—	
Do. Preference	18,	19	—		—	
Direct Spanish	2⅞,	3	—		—	
Do. Preference	7½,	8½	—		—	
Direct United States Cable	9⅞,	9¾	9 11-16		9⅝	
Eastern Telegraph	10⅞,	11⅛	11⅛		10⅞	
Do. 6 per Cent. Preference	14,	14½	14⅝		14½	
Do. 5 per Cent. Debentures, 1899	107,	110	—		—	
Eastern Extension	11⅛,	11⅞	11⅞		11¼	
German Union	10½,	11	—		—	
Globe Telegraph and Trust	5½,	5⅞	5⅞		5¼	
Do. Preference	13,	13½	13½		13	
Great Northern	13½,	14	14		13 9-16	xd.
Indo-European	34,	35	—		—	
Reuter's	7⅞,	8½	—		—	
Submarine	180,	190	—		—	
West India and Panama	⅝,	¾	—		—	
Do. 1st Preference	8½,	9	—		—	
Western Brazilian	8⅜,	8¾	8½		8½	
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	104,	107	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	⅞	—		—	
Oriental	¼,	⅜	5-16		¼	
United Telephone	12½,	13	12⅝		12½	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	2¾	—		—	
Do. (fully paid)	3½,	4¼	3¾		—	
Swan	1½,	1½	1½		—	
Maxim Weston	3-16,	5-16	—		—	

MISCELLANEOUS.

Telegraph Construction	36,	37	37		36½	
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½		23½	

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can be made of all sizes as single Carbon Lamps, from 100 C.-P. upwards, and can be used in parallel circuit with Incandescent Lamps. Any continuous current Dynamo will suit them.

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THE FOLLOWING LAMPS HAVE BEEN MADE, AND HAVE BURNT SUCCESSFULLY:—

Small Parallel,					taking	**50**	volts,	**6-8**	**amperes.**
„ Series					„	**50**	„	**10**	„
Single Parallel, 8 hours,			**2,000 C.-P.**		„	**50**	„	**10**	„
Double „	**16**	„	„	„	„	**56**	„	**12-15**	„
Single Series,	**8**	„	„	„	„	**45**	„	**10**	„
Double „	**16**	„	**3,000**	„	„	**60**	„	**15**	„

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For further information apply to the Secretary, as above.

June, 1887.

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NOTES.

WESTON-SUPER-MARE.—The Taunton Electric Light Company are about to place some arc lamps in the streets of this town.

AYRTON'S "PRACTICAL ELECTRICITY."—We learn that Prof. Ayrton's "Practical Electricity" is now being translated into the German and Spanish languages.

THE FRENCH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—The meeting of the French Association for the Advancement of Science will be held at Toulouse, from September 22nd to 29th next.

THE ELECTRIC LIGHT IN OMNIBUSES.—One of the vehicles of the London Road Car Company running between Liverpool-street and Victoria Station has been supplied with an "Eclipse" primary battery, which is used for lighting an incandescent lamp.

TELEGRAPH EXTENSION IN ZUCATAN (MEXICO). — The extension of the federal telegraph system in Zucatan is to be undertaken at once on a large scale, and it is expected that all the important points in the State will be connected before the end of the present year.

THE BRAY ELECTRIC TRAMWAY.—The application for an Order in Council to authorise the construction of the proposed electric tramway between the Dublin, Wicklow, and Wexford Railway Station at Bray and the entrance to Bray Head will be heard at Dublin Castle on Wednesday next.

ELECTRIC COMMUNICATION WITH LIGHTSHIPS.—The committee appointed to consider the subject of electrical communication between lightships and the shore will report in favour of an eighteen months' trial of the system adopted in connection with the Sunk lightship off Harwich. This cable was fitted by the Telegraph Construction and Maintenance Company.

ELECTRIC LIGHTING IN SOUTH LONDON.—At the last meeting of the Vestry of St. George's, Southwark, a letter was read from the agents for the South Metropolitan Electric Supply Company intimating the intention of the company to apply for provisional orders to enable them to supply electricity for lighting and other purposes in several streets and places in the district.

THE INFANTA OF SPAIN AND ELECTRICITY AS A MOTIVE POWER.—Our Spanish contemporary *La Electricidad* states that the Science and Art Academy of Cadiz has announced a scientific, artistic, and literary competition, and amongst the prizes are bronze and marble vases, offered by the Infanta Doña Isabel, for the best treatise upon "Electricity as a Propelling Power in Navigation."

THE PARIS-ROUEN TELEPHONE LINE.—According to a French contemporary, the telephone line between Paris and Rouen, which was opened for the public service on the 25th June, is working very badly; conversation is said to be most difficult, and at times impossible. This is the result of false economy in the construction of the line, for which galvanised iron wire was employed.

THE LANCASHIRE AND YORKSHIRE RAILWAY COMPANY AND THE POST OFFICE.—Owing to a dispute between the Postmaster-General and the Lancashire and Yorkshire Railway Company, at the end of June last the whole of the telegraph offices at the stations of this company were closed for the public service. The dispute has, however, since been adjusted, and the offices have been reopened.

THE TELEPHONE IN FRANCE.—The following statement shows the extent of the work carried out in France by the Société Générale des Téléphones:—The number of subscribers to the Paris Exchange is 5,010, an increase of 464 during the last six months. There are ten exchanges in the provinces, with a total of 2,283 subscribers, thus distributed—Lyons 720; Marseilles 403; Bordeaux 399; Le Havre 217; Rouen 115; St. Etienne 107; Nantes 105; Calais 95; Alger 80; Oran 42.

TEMPORARY ELECTRIC LIGHTING.—At the ball recently held at the Inner Temple, the marquees, supper rooms, &c., were lit throughout with the electric light, a total of 220 lights of 16 candle-power being supplied from a portable Marshall engine and an Elwell-Parker dynamo placed in Mitre-court. In addition to the above, there were over 120 lights supplied from the permanent plant, which has recently been extended. The work was carried out by Messrs. Drake and Gorham, of 2, Princes' Mansions, Victoria-street, S.W.

RAILWAY CARRIAGE ELECTRIC LIGHTING IN INDIA.—The *Indian Engineer* says that experiments are shortly to be made with a view to the introduction of the electric light into railway carriages in India. Owing to the large distances to be traversed in India night journeys are a necessity; in fact, by reason of the comparative coolness of night travelling, many people prefer trains which run after dark. The carriages are now lighted by the old-fashioned oil lamps, which give only a dim light, and often no light at all when the railway servants omit to trim them.

TRANSFORMERS IN AMERICA.—The Westinghouse Electric Company is meeting with an enormous demand for the alternating system for central station work. The shops employ about 1,200 men and are working a night gang. The lamp factory is already the largest in the United States. There are now over forty stations under construction or in operation. Recent contracts have been made in Pittsfield and Springfield, Mass.; Hartford, Conn.; Denver, Colorado Springs, and Ouray, Col.; St. Louis, Mo.; Cornwall, Canada; Littleton, N. H.; Portland, Me.; Morristown, N. J.; Staten Island, N. Y.; Galveston, Tex., and Charleston, W. Va.

NEWCASTLE EXHIBITION.—The Prince of Wales and his sons visited this exhibition on Wednesday last, and took a ride upon the electric tramway, Mr. Manville having the honour of driving the car upon the occasion. We believe it was also in contemplation to initiate the royal visitors into the mysteries of electric welding, but whether time did not permit, or whether the royal interest was not sufficiently aroused, it at anyrate appears that the Prince did not avail himself of the opportunity of witnessing this most recent and most interesting application of electricity. We may add that we shall shortly give a special description of the electrical specialities of this exhibition, in which will be found some interesting details not hitherto published.

MAGNETISM AND SOLAR PHENOMENA.—Recent observations at the observatory of Lyons have led to some interesting results in connection with the perturbations of terrestrial magnetism. Curves plotted from these observations show that each period of maximum perturbation coincides with the passage of a group of solar spots or a group of faculæ at its shortest distance from the centre of the solar disc. There does not seem to be a relation between the intensity of the perturbation and the diameter of the spots. The conclusion come to by M. Marchand from a consideration of the results is that there is a direct relation between the perturbations of terrestrial magnetism and the displacement in regard to us of certain solar elements accompanying the spots and faculæ.

THE JUBILEE OF THE TELEGRAPH.—A meeting of the members of the general committee appointed to make arrange-

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ments for the forthcoming dinner at the Holborn Restaurant to commemorate the fiftieth anniversary of the construction of the first telegraph in this country was held on Tuesday at the offices of the Society of Telegraph-Engineers, The Sanctuary, Westminster. Mr. W. H. Preece, F.R.S., occupied the chair. A number of details as to the preparations for the festival were submitted by the sub-committee, and discussed, and among other things it was announced that up to date the number of applications for tickets had been about 200, while the guarantee fund amounted to upwards of £250. A meeting is to be held next Tuesday, by which time the committee will be in a position to state their final arrangements.

SHIP LIGHTING.—A very successful electric light installation has just been completed on the ss. "Zaraté," the latest addition to Messrs. Houlder Brothers' line of London and River Plate steamships. The plant consists of a Phœnix compound-wound dynamo, driven with an ordinary leather belt by one of Shanks's Caledonian engines of 6 horse-power, and 100 fifty-volt 16 candle-power lamps. The brackets and pendant fittings are of a new and elegant design, those in the saloon and first-class berths being silver-plated, each fitted with its own combined switch and cut-out. The ship is also provided with deck lights, having a special contrivance for lowering into hold for loading and unloading cargo and embarking passengers at night. The installation was carried out by Mr. Robert Woodley, electrical engineer, of 248, Burdett-road, London.

CONSTANT CURRENT MOTOR-WORKING.—On the occasion of Mr. Wharton's lecture at Bath (referred to in our "Notes" of last week) an Immisch motor was run on the arc circuit lighting the theatre and part of the city. The circuit was composed of 30 arc lamps, two batches of incandescent lamps in parallels of 6, and the motor. The dynamo was a Thomson-Houston one, giving about 2,000 volts and 6·8 amperes. The motor was coupled by a belt to a two foot circular saw. The saw cut through some 4in. deals with ease, and 2in. and 3in. cuts were made as fast as the wood could be fed. The torque of the motor was regulated by a centrifugal governor, which varied the ampere turns in the field. The motor weighed 350lb. and absorbed about 350 volts at full load. This is, we believe, the first time a constant current motor has been run successfully on this side of the Atlantic.

CONTRACT OPEN AT LEON (SPAIN).—*Industries* states that the municipality of Leon offers a monopoly of fifty years for lighting the town with 260 glow lamps of 20 candle-power, burning each on an average 2,200 hours per annum, for the sum of £720. The contractor will be the only person allowed to fix cables or wires for the purpose of electric lighting, whether for public or private lights. No price is stipulated for private lighting. Tenders, which will be opened on the 6th August, are to be on the basis of a diminution of the number of years of the monopoly. Besides the lighting of the streets, the municipal offices are to be lighted by glow lamps of 20 candle-power, to be paid for at the rate of about 0·4d. per hour. The total number of lights likely to be used, including the theatre and private houses, will not exceed 600, but a price of 0·6d. per lamp hour would in all probabiltiy be obtainable.

MOTORS AND AIR PROPELLERS AT WHITELEY'S.—At Whiteley's, in Westbourne-grove, where there is a large electric lighting installation, some trials of electric motors of the Immisch type have lately been carried out with results of such a satisfactory character that it is probable that extensive use will be made of these machines. The new buildings in Queen's-road are already partially ventilated by means of a large Blackman air propeller, and we understand that it is in contemplation to make use of these propellers in connection with small motors instead of the punkahs which are at present at work in some of the departments. During the last few days a half horse-power Immisch motor has been in use for driving an ice-making machine, previously worked by hand. In six minutes the same amount of ice is turned out as previously required half an hour's grinding. The motor has so far been kept continually running from 6 a.m. to 7 p.m., and great satisfaction is expressed at its performance.

TELPHERAGE IN INDIA.—According to the *Indian Engineer*, the "telpher" system of lines is about to be introduced into India, but no details are given. Our contemporary proceeds: "It is stated that the right to erect posts in this country can be obtained for little or nothing, so that the cost would not exceed, say, Rs.7,000 per mile. It would most assuredly be a great convenience in our outlying agricultural districts, and would exactly meet the requirements of the cultivators; and furthermore would be extremely useful in connecting small towns with the nearest points on the main lines. In addition to the 'telpher' there is some talk of the application of electricity to tramways, &c., which apparently is the outcome of Mr. Reckenzaun's paper read before the Society of Arts. It is noteworthy that the water-power we possess from the Himalayas, distributed along our canals, will prove to be an immense advantage, but it remains to be seen whether it will assume a more definite form than discussion as at present."

FELTEN AND GUILLEAUME'S PRICE LIST.—An excellent plan is now being largely followed in making a price list largely available as a work of reference on the subject to which the firm in question devotes attention. In the recently issued catalogue and price list of Messrs. Felten and Guilleaume, the well-known wire makers, this practice has been followed, and we find a great deal of valuable information on the breaking strains of wire-ropes of various diameters and material. This information is conveyed in the form of a series of tables, and great pains have evidently been taken in the compilation. Perhaps in a subsequent issue Messrs. Felten and Guilleaume will see their way to enlarge the electrical sections of their catalogue by the addition of similar tables referring to the electrical constants of their wire. The lightning conductors of this firm made of stranded copper rope, and terminating in five-pronged spears of gilt copper, appear to adequately fulfil the conditions which the most recent theory has shown to be necessary.

ELECTRIC LIGHTING ON RAILWAYS.—The following paragraph appears in the *Lancet* of July 2nd:—"There are certain blunders of omission or commission in policy which appear inexplicable. One of these is the omission to light railway carriages by electricity, and another the recourse to gas and other highly dangerous appliances of illumination. The peril of travelling reservoirs of gas has been painfully illustrated of late. It is strange that any company has had, and still has, the hardihood to subject its passengers to the very grave peril which besets the use of gas in this way. More wonderful still is the neglect to use the motor force available for the self-generation and storing of electricity. Surely there would be no great difficulty in so adapting the necessary apparatus as to make the moving wheels of the carriage do the work of an engine. It is needless to emphasise this suggestion. There is, of course, nothing new in the idea, but it seems to be one of those very obvious matters which are seemingly too plain to be perceived, or in some way fail to impress that particular part of the mental constitution which we call the common-sense

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instinct. The task of providing trains which travel at night with special accumulators cannot be overwhelming. Those trains that travel by day, and only require lights for tunnels could, we imagine, be utilised to charge the accumulators required by night trains."

THE TELEPHONE SIREN.—At the last meeting of the Berlin Electrical Society, Prof. Karsten described his telephone siren. The instrument (says *Industries*) consists of a disc, to the face of which are fastened radially small steel bar magnets. This disc is revolved by clockwork, and the pole of an ordinary Bell telephone, with diaphragm removed, is presented to the rim of the disc. The rapid passage of magnet poles induces currents in the telephone, and a musical note is produced in a telephone receiver connected with the siren. If all the magnets present the same polarity outwards, the number of complete waves produced during one revolution of the disc equals the number of magnets; if, however, the magnets are placed with alternating polarity, the number of complete waves is half that of the magnets, but the waves are stronger. In this case the tone heard in the receiver is the lower octave of the tone in the former case. It is also possible to arrange other combinations; for instance, if the poles are placed in the succession N N S, N N S, &c., the tone heard is the fifth of the former. Prof. Karsten has found that this combination gives tones most readily distinguished by the human ear, and he recommends it where this apparatus is to be employed for the measurement of resistances by the use of a telephone instead of the galvanometer in bridge tests. He finds that the sound given by the siren is more easily distinguished from accidental noises, which often accompany the employment of the usual make and break arrangement. By combining the siren with an anemometer it is possible to tell the strength of the wind from the tone produced in the receiver.

A "NEW FORM OF ELECTRICITY."—M. le Dr. Luce has made a very singular discovery—nothing less than "a new form" of electricity. This discovery was made by the learned doctor some five years ago, and has only now been communicated to the world through the medium of a brief letter in the columns of the *Bulletin de la Société International des Electriciens*. From this letter we may quote the principal passages (translating *verbatim et literatim*) which summarise the discovery:—"(1) In a conducting medium the formula of propagation is $I = I_1 - KD$; K being the coefficient of absorption of the medium, I the force at the distance D, and I_1 the initial force. (2) It follows the contour of a wire, but has a great tendency to propagate itself in a right line. (3) Its velocity is some metres per second. (4) Its conductors and its insulators differ notably from those of ordinary electricity; I have called it the *forme nervique* because its properties upon the whole closely resemble those of nervous propagation, if indeed they are not identical. (5) It can be developed by motion, heat, magnetism, or voltaic electricity. (6) The most practical method of evidencing its existence is the sensation which it produces in the hand, or the variation of temperature which it causes in a thermometer held in the hand. (7) I have employed this agent in the treatment of all forms of disease and for five years it has enabled me to avoid the use of medicaments amongst my numerous patients." On reading these closing lines some subtle association of ideas brings irresistibly before us the peaceful images of rural life, and we seem with startling clearness to hear the sound of the duck-pond and the poultry yard.

HARGREAVES' HOT-AIR ENGINE.—The annual report of the Chief Inspector, appointed under the Alkali Works, &c., Regulation Act, 1881, which has just been issued, contains the following:—"While this report is passing through the press a communication reaches me which has so important a bearing on the smoke question, and must be of such great interest to manufacturers generally, that I embrace the opportunity of inserting it. Mr. James Hargreaves, the well-known chemical manufacturer at Widnes, the inventor of the process for the manufacture of sulphate of soda which bears his name, has for several years been engaged on the production of a hot-air engine in which the energy of the fuel consumed should be much more completely converted into motive power than is the case in the steam engine of the present day. His efforts have so far been crowned with success that he can produce 30 indicated horse-power from a consumption of two gallons of common coal tar per hour. This, he adds, 'is the highest efficiency ever obtained by actual practice in any form of thermodynamic engine, and also the least costly. At present prices it is equal to 20 horse-power, or 1d. per hour.' The fuel may be gas tar, paraffin oil, or other liquid hydrocarbon, or it may be coal. In any case the combustion is far too complete to admit of the emission of black smoke. The combustion is carried on in a small but intensely heated chamber or furnace, the fuel being forced in under pressure. This is a step towards the removal of that large proportion of the smoke nuisance which is caused by the fire of steam boilers, and may be viewed as an approach to the fulfilment of Sir F. Bramwell's prophecy, that fifty years hence the steam engine will be regarded as an antiquated machine."

ESTIMATES OF RELATIVE COST OF ELECTRIC AND GAS LIGHTING.—Herr Oelwein, in a lecture to the Austrian Engineers' and Architects' Association, gives the following data as the relative cost of electric and gas lighting. His bases are:—gas burners, 16 candles, 4½ cubic feet; 7 incandescent lamps per horse-power; 150 lamps of either kind fitted up; price of gas 5s. 8¼d. per thousand cubic feet; sinking fund, &c., for electric apparatus 12½ per cent.; for gas fittings 10 per cent. The figures show the costs per hour in pence:—

Hours Consumption.		Incandescent.				Gas Light at 5s. 3½d. per thousand cubic feet.
		Steam engine.		Water-power existing.	Gas Motor.	
Yearly.	Daily.	Existing.	New.			
500	1·38	0·27d.	0·59d.	0·222	0·688d.	0·242
800	2·19	0·21d.	0·44d.	0·163	0 567d.	0·228
1,200	3 29	0·174d.	0·34d.	0·130	0·489d.	0·222
1,800	4.93	0·144d.	0·27d.	0·105	0·428d.	0·216
3,600	9·87	0·123d.	0·20d.	0 085	0·382d.	0·213

The *Gas World* adds to this as follows:—If the gas be 2s. 6d. per thousand cubic feet, we find that, on the given data (including the cost of gas motor, 22 horse, at £550, cost of incandescent lamps, &c., at £525. 8s., and cost of gas fittings at £150. 16s.), the cost per hour becomes:—

Hours Consumption.		Incandescent, with Gas Motor and Gas, at 2s. 6d.	Gas Light at 2s. 6d.
Yearly.	Daily.		
500	1·38	0·518d.	0·126d.
800	2·19	0·397d.	0·113d.
1,200	3·29	0·319d.	0·106d.
1,800	4·93	0·258d.	0·099d.
3,600	9·87	0·212d.	0·097d.

WHAT IS ELECTRICITY?—In another column will be found an abstract of an interesting paper read at a recent meeting of the New York Electrical Society by Mr. Townsend Wolcott. Mr. Wolcott's point of view is one which we confess commends

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itself forcibly to our judgment. He dissents *in toto* from the idea that there is any objective or subjective necessity requiring that we should express "electricity" in terms either of matter or of energy. In fact, we are reduced in Mr. Wolcott's opinion to the statement that electricity is *sui generis*. Electricity *is*—electricity. Personally, however, we think that it must be admitted that we do not go beyond the limits of our knowledge of the facts if we venture the assertion that "electricity is a vehicle of energy." This may not help us very far as a definition, but the statement has the merit of implicitly containing a denial of the notion that electricity is a form of energy, while leaving open to discussion the more plausible idea that it is a form of matter. It is somewhat surprising that the demonstration that electricity is not a form of energy does not as yet appeal very strongly to all who might be supposed capable of appreciating the argument. Only a few months ago, in an important paper by M. G. Cabanellas, the opposite opinion was stated with much vigour, though with little or no argument in support of the assertion. "Some *savants*," said M. Cabanella—"even men of talent, who, however lack the true philosophical spirit—think that electricity is not a form of energy, and have tried to establish this view, it is needless to say in vain. The history of science contains in fact many of these chimerical notions where truth has been sacrificed to the taste for the marvellous." Thus M. Cabanella, to whom we would with due respect rejoin that

"There are more things in heaven and earth, Horatio,
Than is dreamt of in your philosophy."

Surely, one of the most impressive facts of modern science is found in the number and importance of the phenomena which we are still unable to express in terms of length, time, and mass.

THE BRITISH ASSOCIATION.—At a meeting of the local executive committee for the British Association, held last week in Manchester, the guarantee fund was reported as amounting to £10,345, a sum which is sufficient for the present without any further call on guarantors. The committee propose to provide space in the gallery of the Natural History Museum for the exhibition of instruments and specimens shown in connection with the sectional meetings. The Evening Entertainments Committee reported that the Mayor of Manchester had invited members and associates to a *conversazione* in the Town Hall on Tuesday, September 6th, and that the soirée kindly offered by the Executive Committee of the Royal Jubilee Exhibition had been fixed for the evening of Thursday, September 1st. It was stated that the lecture to working men, by Mr. George Forbes, F.R.S., on the evening of Saturday, September 3rd, would be on the electric light, and the Manchester and District Edison Electric Light Company (Limited) had undertaken the experimental illustrations in connection therewith. The Hospitality Committee reported that their efforts to secure the presence of eminent foreign men of science at the meeting had met with great success. Of those invited nearly 100 have already accepted, including Americans, Germans, French, Russians, Belgians, and men of other nationalities. Not merely will the numbers be altogether unprecedented, but in each of the leading branches of science the most eminent foreign representatives will be present. In physics, chemistry, and biology the attendance will be exceptionally large, and in these subjects the meeting is certain to produce permanent results of great value to science. The Excursions Committee reported that a list of thirteen excursions had already been arranged for Thursday, September 8th, the list including Chester, Chatsworth, Bolton Abbey, Hornby Castle, Crewe and Horwich Railway Works, Stonyhurst, and the Isle of Man. For Saturday, September 3rd, several excursions have already been arranged, including one to the salt-mines at Northwich, to Tatton Park, to Buxton, Knutsford, &c., and a marine dredging expedition will be made from Liverpool. At an influential meeting held at Leeds last week, under the presidency of the Mayor, it was determined to invite the British Association to that town in 1890.

THE SOCIETY OF ARTS.—TRIALS OF MOTORS FOR ELECTRIC LIGHTING.—In our issue of December 17th, 1886, we announced that the Society of Arts proposed to award two gold and two silver medals to the best motors for electric lighting purposes, and we printed the conditions of the competition at full length. The notice given was rather short, being only about two months, and it was intended to hold the trials in London in May or June of the present year. In January, however, the conditions were revised, and the trials postponed until May, 1888, while the time of entering for the competition has been extended up to 31st December, 1887. It is very much to be desired that this competition should be warmly entered into by the leading firms of engine makers, for if this should be the result we have no doubt that the trials will have a beneficial effect upon the electric lighting interest in general, as well as upon the important question of the best type of motor. We think, however, that it is to be regretted that the society has not seen fit to subdivide the classification of the engines still further. At present there are two classes, A and B. A consisting of "motors in which the working agent is also produced," such as steam engines with boilers, and gas engines with gas producers. Class B, consisting of motors to which the working agent must be supplied, such as steam engines without boilers, water and air engines, &c. From an electrical engineering point of view it would have been more to the purpose to have divided the motors in accordance with the requirements of the electric installation for which they were to be used; as, for instance (1) Engines for central lighting stations; (2) For ship lighting; (3) For large isolated installations; (4) For domestic installations; (5) For arc lighting. Some of which classes would perhaps bear still further sub-division. These various types of installation possess such varying requirements that it is impossible to select any one type of engine as the "most suitable for electric lighting" without further particularising. We much fear that these considerations, which are patent to every one interested, will operate to restrict the number of entries, and we would beg respectfully to urge the attention of the Society to the matter while there is yet ample time to reconsider the scheme. The revised regulations are nearly word for word the same as in the first issue, but have been extended to include air engines of all types, and engines working with any hydrocarbon liquid or vapour.

ELISHA GRAY'S TELAUTOGRAPH.—The following paragraph appeared in the Chicago *Tribune* of 25th June:—"Prof. Elisha Gray, of telephone fame, is perfecting an invention with wonderful possibilities, and one which promises great results. It has already reached that stage which ensures its practical success, the experiments thus far proving eminently satisfactory The 'telautograph' is the name by which the instrument will be known, which, by the way, conveys a very fair idea of what the instrument really is. Once in operation it will be possible for the Chicago speculator to deliver to his New York broker a telautographic order to buy or sell 1,000 or 10,000 shares of railroad stock, an exact fac-simile of the order being reproduced in that city at the same instant it is written here. If the Chicago man happens to be in New York and wants to send his wife a check for money, he simply writes it out in that city, and the moment he is through it is in his wife's hands:

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here. The electric current, of course, is an important factor in the invention, but the chief feature is the plate or instrument on which the writing is done. No particular kind of pen or pencil has to be used; in fact, a sharp-pointed instrument of any kind, or even a piece of wood, will answer the purpose. The paper on which the writing is done and the autograph reproduced does not have to be prepared, for in the first instance it is the pressure on the plate which gives the impulse to the machine, while the reproduction is brought about by a tracing point, which may be a properly-inked pen or even an ordinary lead pencil attached to a movable arm in the receiving machine at the other end of the line. A number of experiments with the machine have been made at Highland Park, where Prof. Gray's laboratory is, all of them of the most satisfactory character. The circuit was not a very long one, but the tests were of that kind which indicated that the length of the circuit did not matter much and that the work could be done over 1,000 miles of wire as perfectly as over 100. Prof. Gray has not yet applied for patents on the invention, but it is fully covered by caveats, so that he has removed the injunction of secresy and feels free to talk upon the subject with his friends. He is inclined to think the machine will be required in all cases where absolute accuracy in the delivery and filling of an order is required, and that it will eventually supersede the present system of telegraphic communication; in fact, that an operator will simply transcribe a message, and, while in the act of so doing, will wire it to any point on the continent, the reproduction at the other point always being a fac-simile of the writing of the person at the machine."

THE RECREATIVE EVENING SCHOOLS ASSOCIATION.—We would invite the attention of our readers to the interesting and important work in the spread of elementary scientific knowledge which is being carried out in London by the Recreative Evening Schools Association. The object aimed at by the Association, of which the Princess Louise is president, and which is actively supported by men of eminence in science, art, and literature, is, in brief, to carry the education of the children of the working classes to a stage of culture beyond that which is obtained in the Board Schools. The scheme is applicable to not less than 400,000 London children, and is dependent solely upon the voluntary help of those who interest themselves in the work. We need say nothing to commend the work of the Association to the sympathy of our readers, and there are doubtless some who will be glad to render active assistance. The Science Committee of the Association, consisting of the following gentlemen, H. G. Rawson, Esq., chairman; W. Lant Carpenter, Esq., C. D. Barker, Esq., Le Blanc Smith, Esq., Prof. F. Jeffrey Bell, F. W. Rudler, Esq., J. J. Harris Teal, Esq., J. Edward Flower, M.A., secretary, has recently issued the following circular letter:—"Lectures on Elementary Science.—The following is the list of subjects selected for courses of Simple Science Demonstrations, with or without lantern illustrations, in evening schools in winter. Each course to consist of ten or twelve lectures of a thoroughly popular but educational kind. Each lecture to be of about 45 minutes' duration. The scholars range from 13 to 18 years of age. The proposal is that each lecturer should give the whole course of lectures on the subject he may select, and in the same school or neighbourhood, in consecutive weeks. About 50 lecturers will be required, in order to supply all the schools. Any gentleman willing to give help is invited to send his name and address, the branch of science he professes, and the locality in which he would prefer to teach, to the secretary at the above address. List of subjects for lectures: *A. Chemistry and Physics*—I. Chemistry (Inorganic). II. Physics. 1. Elementary mechanics and pneumatics. 2. Elementary physical properties of air and water. 3. Sound. 4. Light. 5. Heat. 6. Magnetism and electricity. 7. Physical astronomy. *B. Biology*—1. Elements of animal physiology. 2. Elements of vegetable physiology. 3. Structure of leading forms of animal life. 4. Structure of leading forms of vegetable life. *C. Geology and Physiography*—1. Physical geography. 2. Stratigraphical Geology:—The history of the earth revealed by the stratified rocks. 3. Palæontology:—Leading forms of extinct life; fossils, coal, &c." Communications should be addressed to the secretary, at 37, Norfolk-street, Strand, W.C.

OPTICAL DEMONSTRATION OF THE ACTION OF THE TELEPHONE.—The following abstract of a paper in the *Electrotechnische Zeitschrift* is taken from the number of the *Proceedings* of the Institute of Civil Engineers which has just appeared:—"The mechanical movement of the diaphragm of the telephone, if actuated by powerful currents, can be shown by the nodal lines formed by lycopodium dusted on its face; but if the current be generated by a microphone or by another telephone actuated by singing or speaking, not a trace of a Chladni's figure is produced. By affixing a small mirror, however, between the centre and circumference of the diaphragm, and reflecting therefrom a beam of light on to a distant scale or telescope, its motion can be detected; but for a lecture demonstration the best method for exhibiting this motion is to fasten a stretched wire to a projection on the centre of the diaphragm, and fix a mirror longitudinally on the wire between a loop and node, by which means a movement of 18 inches or so can be given to the spot of light on the scale; the form of the vibration is, of course, not reproduced in this latter instance. If mirrors be fixed to both the actuating and receiving instruments, the beam, after reflection from both being thrown on a screen, as in Lissajou's method, the figures observed afford a most simple means of illustrating the deformation of the musical notes or vocalisation which results from the action of the diaphragm itself. For the most accurate examination of the movement of the telephonic diaphragm the author has adopted König's method of dancing flames analysed by a rotating mirror, and outline diagrams of the different forms of the vowel sounds as sent and received, revealed by this method, are given. The effect of the introduction of electrical resistance, capacity or self-induction in the circuit, as regards the alteration and interconfusion of the different vowels or consonants, is thereby clearly revealed, and is due not so much to reduction of the intensity of the sound as to the rounding off of the current-waves. The permanent record of these flames could not be photographically produced with ordinary gas, but a certain degree of success followed the use of bisulphide of carbon vapour burning in nitrous oxide gas, as by this means the maxima or ridges of the flames were clearly developed, though the minima or furrows were somewhat indistinct. The author proposes the application of this method for testing dynamo machines, as by it can be seen the actual progress of the phase in the alternating current, or the impulse at the passage of the brush over each commutator plate in the continuous current. It could also be conveniently applied for chronographic measurements—*e.g.*, the velocity of projectiles in the gun tube; let the shot contain an iron bar, and the gun be surrounded by a series of coils which are in connection with a telephone and some source of electric current; then the time of the passage across the plane of each coil can be actually recorded on the photographic plate, the great advantage of this method lying in the fact that the gun tube need not be tampered with, and that one or two sets of coils would suffice for guns of any calibre."

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 138.)

We come now to the field-magnets. The degree of saturation assumed in the armature core was $\sigma = \frac{20}{25} = \cdot 8$, and taking as average iron for the magnets that which is practically saturated at eighteen lines per square inch, and making $\sigma_1 = \sigma$ we proceed to find the section of the cores.* First, however, it is necessary to know the value of ρ, the resistance of the air leak. Unfortunately the writer of these papers has not got any experimental figures on which to base this quantity, excepting for four-pole machines of the new Gülcher type, and for two-pole machines having side cheeks and standing poles downwards.

In these last-named, the numerator constant was 355, but in such a machine as the one under consideration this value will be too small, because the leakage emanates from a much smaller surface; it will also greatly depend on which way the machine is set on the bed plate, the least leakage taking place when the poles stand upright away from the bed-plate. In such machines Mr. Kapp has found 500 to be a fairly approximate constant to use, but since the more general practice is to place the poles downwards, as in the Edison-Hopkinson machine, we will take 400 in the present case.

The magnetic resistance of the armature core must now be found. It is expressed by the fraction $\frac{\text{mean length}}{\text{cross section}}$, the factor 2 being omitted because the lines pass through the two sides in parallel. Thus

$$R_A = \pi \frac{\left(R - \frac{p}{2}R\right)}{p q \gamma R^2} = \frac{3 \cdot 46\pi}{17 \cdot 12} = \cdot 636.$$

The total number of lines passing through the armature core is

$$Z_1 = \frac{117 \times 10^6}{174 \times 1000} = 672,$$

that is 336 passes through the area 17·12; the density is thus

$$\sigma_1 = \frac{336}{17 \cdot 12 \times 25} = \cdot 785.$$

The discrepancy between this figure and ·8, which was originally assumed, is due to the practical necessity of adjusting R to the English measurement of $4\frac{5}{8}$in.

The coefficient of saturation will now be

$$K_1 = \frac{\tan \frac{\pi}{2}\sigma_1}{\frac{\pi}{2}\sigma_1} = 2 \cdot 3$$

The real resistance of the armature core is therefore $K_1 R_A = 1 \cdot 46$.

It must be remarked that this figure is undoubtedly higher than it should strictly be, because we have here considered the mean length of the passage through the core as represented by a complete semi-circle drawn halfway through its thickness, but the error is probably small, and is, moreover, on the right side. In the same way the cross section of the air space δ will be considered to correspond with the core surface of equal angle with the pole shoe. The clearance between the outside of the winding and the interior surface of the pole shoe, which is necessary to mechanical safety, depends very much on the quality of the workmanship expended in the winding. When the core is made up perfectly true and the winding is carefully performed it need not be more than $\frac{1}{8}$in. in an armature of 1ft. in diameter.

* With reference to the discrepancy between the practical saturation density of iron in armature and field-magnet cores, it may be noticed that the experience which has led Mr. Kapp to limit the saturation of the external field to 18 lines per square inch is fully in accord with the experiments by Prof. Ewing, who found that far higher inductions could be obtained in comparatively small masses when placed in heavy fields than when directly excited.

It is generally held that in practice this quantity is far nearer a constant than a simple linear function. This, however, is not the author's experience; on the contrary, the clearance always has to increase with the dimensions, and for all but exceedingly small machines this variation can most suitably be made to take place strictly with the linear dimensions.

By the rule given above, the clearance in the present machine would be ·096, let us say ·1, which, added to the depth of the single layer on the outside of the core would give $\frac{\cdot 11}{\mu} + \cdot 1 = \cdot 26$.

The angle covered by the shoe must not be so great as to cause an excessive leakage of magnetic force across the space intervening between opposite poles; 135° will be a maximum in two-pole machines, and about 55° in those with four poles.

The pole surface will thus be

$$\frac{135}{360} \cdot 2\pi R \cdot q R = 101;$$

the air resistance is therefore

$$R_a = \frac{1440 \times \cdot 52}{101} = 7 \cdot 41.$$

The exciting power p_1 necessary to force 672 lines through the resistance $K_1 R_A + R_a$ is thus

$$672 \times 8 \cdot 87 = 5950.$$

The leak z which will take place under this pressure is

$$z = \frac{p_1}{\rho} = \frac{5950 \times 9\ 25}{400} = \text{say } 138.$$

The total number of lines which pass through the field-magnets are therefore $z_2 = 672 + 138 = 810$. Assuming practical saturation at 18 lines per square inch, and $\sigma_2 = \cdot 8$, we have the section of core

$$AB = \frac{810}{18 \times \cdot 8} = 56.$$

The length of armature core $q R = 9\frac{1}{4}$in. Thus the short diameter of the magnet section will be

$$\frac{56}{9 \cdot 25} = 6\ 05\text{in.}$$

and the depth of winding

$$\frac{6\ 05}{4} = 1 \cdot 51; \text{ say, } 1\tfrac{1}{2}\text{in.}$$

It is always best to make the magnet bar in two or more pieces, so as to assist the ventilation as much as possible. In the present instance two bars, each $4\frac{1}{2}$in. × $6\frac{1}{4}$in., set edgeways, with $\frac{1}{4}$in. between them, would constitute a good arrangement; the perimeter would then be $2(6\frac{1}{4} \times 9\frac{1}{4}) = 31$in., which may also be taken as the number of square inches of surface per linear inch of core, and as the watts per linear inch of winding. In modern compound-wound dynamos the shunt current is, as a rule, about $\frac{1}{20}$ of the main current, and the shunt winding constitutes about $\frac{3}{4}$ of the total exciting power. The number of turns in the shunt winding will thus be about 60 times as many as in the series, and the average current in the whole winding will be $\frac{1}{15}$ of the total current. The above rough estimate is based merely upon the average value of shunt current in machines of ordinary dimensions, and it is made in order to furnish the first datum for finding μ.

Of course, the same remarks which were made with regard to this quantity in dealing with the armature winding apply here also, and it is necessary to make a preliminary assumption for the section of wire A on the basis of its conveying the current $\frac{105}{15} = 7$ amperes. Suppose we fix the density provisionally at 1,200 amperes per square inch, the section $A = \frac{9}{1200} = \cdot 00583$, and the diameter of a circular wire of corresponding area = ·086in. Then for this circular wire

$$*\mu = \cdot 885 \times \frac{\cdot 086}{\cdot 086 + \cdot 02} = \cdot 72.$$

* In magnet winding with circular wire ·02in. is the maximum thickness of cotton.

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Turning now to the equation $\frac{d\,l\,\mu^2}{162\times10^4\times A^2}=\frac{w}{C^2}$ given on page 27, Vol. XIX., we have $d=1\cdot5$ and $l=31+1\cdot5\pi=35\cdot72$in.; we thus get A = ·00521 sq. in., which gives $\mu=\cdot71$—assumed at ·72. For future machines of this type A will be at once known from the equation

$$\text{density}=a\,L^{-\frac{1}{2}}$$

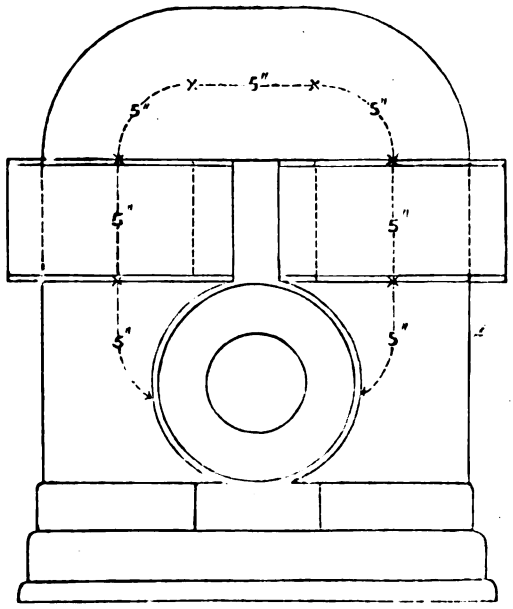
where L is one dimension of the core section and a is a constant; μ can then be taken out of the equation direct.

The number of turns per inch will be

$$n=\frac{\mu^2\,d}{A}=\frac{\cdot505\times1\cdot5}{\cdot00521}=146.$$

It now only remains to determine the total exciting power P in order to complete the dimensions of the magnets. To do this it is necessary to find the magnetic resistance R_F, and we must therefore assume some length for the winding as a first approximation.

The length L on which R_F depends consists of three parts, the mean path of the lines through the yoke, the length of the exciting bobbins, and the mean path of the lines through the pole shoes. Referring to Fig. 13 it will be seen that in our design the first length equals $5+3\cdot125\pi=14\frac{7}{8}$in., and the mean path through the pole shoes will be about 10in. in the



Scale—One-eighth of full scale.

Fig. 13.

two sides. An average length for the winding on such a machine would be about 5in. for each bobbin, and assuming this length provisionally we get a total length of $34\frac{7}{8}$, or, say, 35in. Then $R_F=\frac{70}{56}=1\cdot25$, which, multiplied by 2·45 (since $\sigma_2=\cdot8$ and $\therefore K_2=2\,45)=3\cdot05$; thus $p_2=810\times3\cdot05=$ say, 2500, and $P=p_1+p_2=8450$. For the purposes of designing the carcase of the machine, it would be safer to increase this figure a little and say P = 9000; we then get the length of winding as

$$\frac{P}{2Cn}=\frac{9000}{2\times7\times146}=4\cdot4\text{in.}$$

The thickness of the cases and end insulating washers will just make up the 5in., so that the value for R_F will remain correct.

Having now arrived at all the dimensions of the proposed machine, it is possible to draw the characteristic curve of total E.M.F. by assuming various values for P between 9000 and zero, and then calculating the corresponding E.M.F. for each by the formulæ already given. Since it has been necessary at several points to accept a probable approximation in place of experimental data, it is not to be expected that a curve so drawn should coincide with the experimental curve so closely as would be the case were all the data obtained from actual observations with a machine of this type. If the character of the curve be correct, however, the machine may be compounded directly from it, and the only necessary adjustment, if any, will be one of speed. Of course in practice on any large scale it is generally preferable to experiment with a spare set of bobbins before attempting to calculate the relative strengths of the shunt and series winding; but still cases sometimes occur where it would be of great convenience to determine them at once.

To do this it is only necessary to take such an exciting power p on the line O X as will give the required E.M.F. on O Y, since on open external circuit the slight fall of potential due to the resistance of armature and series winding, and also the self induction, may be neglected. Then $p=\frac{E}{r_s}.n_s$, where E is the E.M.F. required on open circuit, and n_s and r_s the number of turns and resistance of shunt winding respectively.

Thus $$\frac{n_s}{r_s}=\frac{p}{E},$$

also $$r_s=\frac{\text{length}}{162\times10^4\,A_s}=\frac{2\times l_s\times n_s}{162\times10^4\,A_s},$$

where l_s is the length of a mean convolution; whence

$$A_s=\frac{2\times l_s\times\frac{p}{E}}{162\times10^4}$$

all of which quantities are known.

With regard to the number of turns it may be remarked that since the resistance r_s varies directly with n_s, p will remain constant providing that no variation occurs in l_s; in practice, therefore, after having wound on the series wire, the magnet case is filled up with the shunt winding. In calculating the series winding it must be remembered that the exciting power due to the shunt will increase in direct proportion to the E.M.F., so that if, as is usually the case, a higher E.M.F. is required with full load than on open circuit, a proper allowance must be made for the increased shunt power.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—XX.

BY J. SWINBURNE.

Testing.

The first thing to test is the vacuum. The usual way is to pass the spark from an induction coil through. If one terminal of a Ruhmkorff coil, giving about a half-inch spark, is connected to the terminal of the lamp, and the other is led to a wire tied round the bulb, and the lamp gradually exhausted, the discharge is purple or lilac at first, with pinkish lights round the carbon. As the vacuum gets better the discharge becomes bluer, and if the bulb is made of German glass it gradually changes to bright green. The green is distributed through the bulb at first, but as the vacuum gets better it is confined to the internal surface of the glass; it then appears only in patches on the glass; and finally it disappears altogether. It is difficult to get it to disappear altogether. If the bulb is made of English or lead glass the discharge is never of the brilliant apple-green seen in the case of German glass; it is of a bluish colour till it disappears.

The primary coil need not be supplied by a primary battery, as the cells are very troublesome. It is best, therefore, to connect it with a dynamo and resistance, or to work it from a secondary battery. If it is put in circuit with a dynamo with resistance in series to reduce the electromotive force, a lamp should be put in shunt to the primary coil and contact breaker, otherwise the sparking is troublesome and soon destroys the contacts. One terminal of the secondary is led to a plate and the other to a loop about an inch off, so that when the lamp is taken by the tip and held in the loop the

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terminals touch the plate. In testing lamps with very thin or weak carbons it is best to take the lamp in the hand and touch one terminal of the coil only, as, if the lamp has a powerful discharge passed through it the carbon is often broken. Sometimes the carbon remains some minutes stuck against the glass after the discharge. Lamps will also frequently glow in the dark after the discharge.

A large number of lamps can be tested for vacuum very quickly. Those which do not show either a bright apple green on the glass if German, or no discharge at all, are rejected. Any rejected lamps are examined; if there are any cracked at the sealing in they are sent back to the glass blowers' room to be repaired if possible. To repair such a lamp, the nose is held for a moment in the blowpipe flame, which cracks it. The lamp is left till the vacuum is destroyed by the slow leakage thus produced. The nose is then knocked off, and a new exhausting stem is sealed on. It requires some practice to do this neatly, but with care a lamp may be repaired so well that no one could tell it had been exhausted twice. The cracked end is then very slowly and carefully heated and worked till the crack is gone. The lamp is then sent to the pump room in the usual course. If the lamp is merely badly exhausted, a new exhausting tube is sealed on, and the lamp pumped again.

The current opinion is that the vacuum in a fairly well exhausted lamp is about one in a million, and that the Ruhmkorff coil is an infallible means of testing the vacuum.

The writer has come to the conclusion that this is not the case, and that the vacuum generally obtained is not more than about 1 in 20,000. The whole question demands further experiment, as the results obtained so far are conflicting, and there are not enough data to draw conclusions with certainty. In the first place, mercury vapour must have some tension. It seems to have been generally assumed by those who have worked at high vacua that it has no tension. Regnault found the vapour tension of mercury at 20°C.—which may be taken as the average temperature in a pump room—to be ·0372 mm.; this would give 1 in 20,000 as the maximum vacuum obtainable by any mercury pump. Apart from Regnault's determination, the mercury must have an appreciable vapour tension, for it evaporates perceptibly at ordinary temperatures. If a piece of gold leaf is held near mercury it is soon amalgamated. It seems, therefore, probable that the mercury pump ceases to take out air when the pressure is about equal to that of the mercury vapour itself. This would show why a Geissler pump goes on taking air out after a Sprengel stops, as the mercury in a Sprengel, being violently broken up, would give off vapour more easily. The action of the pump would of itself lead one to suppose that some such action takes place. If a Geissler pump, with a bulb the same size as, say, one lamp and the phosphoric and other tubes were set to exhaust the lamp, beginning with a pressure of 10 mm. of mercury, it would reach a vacuum of 1 in a million in 14 strokes, if the glass gave off no air. The glass, of course does give off air, so the pump takes considerably longer. But if the pump really brought the vacuum up to one in a million, it is not likely that the gas would be given off gradually, so that the vacuum soon rose to one in 200,000 or 300,000, and then rose to one in a million very slowly, never getting much better. If the Geissler is worked till it shows a vacuum that would generally be called one in a million, and then left for some hours, the vacuum will apparently have fallen to about what would be called one in 100,000. Even if the lamp be heated very strongly and be pumped for several days, it will show a so-called vacuum of only one in 20,000 or so after standing, though it showed one in a million at the last stroke of the pump. When a Geissler pump is worked till it shows a so-called vacuum of one in a million, it goes on for some time with only slight improvement of the vacuum. If the vacuum were really one in a million or so, and the air delivered by the pump were approximately equal to the air coming off the glass, which is the accepted theory, the vacuum would immediately fall to one in 500,000, if the pump were allowed to miss a stroke. It does not do this, however; the apparent vacuum falls very slowly. This is easily explained on the mercury vapour theory, as the bulb of the pump would be nearly full of mercury vapour, a little air coming in to every stroke, so that the apparent vacuum would increase very slowly. If the pump is left for some hours the air would diffuse into the pump bulb, and the mercury vapour would also find its way into the phosphoric tube and lamp. This would also explain why the apparent vacuum should fall off so much when the pump is allowed to rest for a day or so.

To return to the spark from the induction coil. It has been already mentioned that no spark will pass through the bulb of a good Geissler pump while the mercury is descending, until the end of the tube from the lamp is uncovered. It was known in the last century that pure mercury vapour does not carry any spark. A Torricellian vacuum was made, the mercury having been very thoroughly boiled in the tube. It was found that the spark from an induction coil did not pass. When a little air was admitted, however, the bright green light appeared at once. Mercury vapour, therefore, contrary to the statements generally made, will not pass a spark unless air is mixed with it. As already mentioned, mercury seems to sweep the air off the glass, so that the Geissler bulb contains pure mercury vapour when the mercury is descending, but the spark can pass immediately the end of the lamp tube is uncovered.

Another way of testing vacua, which is only applicable in experimental work, when the lamp is not wanted, is to open the bulb under mercury. It requires care to perform this operation properly. If a lamp is merely held with its nose under mercury, and if the nose is then broken with a pair of pliers, the mercury will leave a bubble of air about the size of a bean. Most of this has come in from the outside, as there is a film of air upon the outside of the lamp, and especially on the jaws of the pliers. If the nose be broken so as to make a very small hole, and if the jaws of the pliers or any such thing be held against the tip, bubbles of air will be seen to come into the lamp. The best way to prevent this source of error is to wet the lamp and pliers with water or oil. If a number of lamps which have broken terminals, or are wasters from some other cause than bad vacua, are taken and tested with the induction coil, and are then opened under mercury, it will be found that those which showed what would generally be considered the best vacua on the coil do not always show the least air when opened under mercury. The air bubble generally left when a lamp is opened under mercury would correspond to a vacuum of about one in 10,000 to one in 20,000; but sometimes the mercury fills the whole of the inside of the lamp, showing a perfect vacuum. It is probable that the air condenses against the glass, and that this test is of little or no value. Davy found that when the mercury was allowed to rise to the top of a barometer tube slowly it left a bubble, but when it was allowed to come up with a bump, the bubble did not appear and the air seemed to be flattened out against the glass.

Sometimes a lamp passes no spark, or shows bright green spots after it has been lying in the store for some time, but after running it will show a much lower vacuum on the coil. If left for some time the vacuum will appear to improve again. It seems as if the gas inside condensed on the glass, and was driven off by the heat when the lamp was run. The passage of sparks also seems to bring off gas from the glass. This effect may be best observed while exhausting a lamp. The vacuum of the lamp can also be apparently reduced by merely heating it.

Sometimes lamps, especially those for high electromotive force, or badly exhausted, show a blue light flickering about on one end of the carbon. There is a curious phenomenon in connection with this blue light. If a lamp which shows it is run still brighter the blue light generally gets worse and leaves the terminal, and spreads until the whole of the inside of the lamp becomes filled with bright blue light. If the lamp is overrun for some time, the blue light begins to flicker, and the flashes get fewer till there is only an occasional flicker visible. Finally it disappears altogether. It cannot be made to appear again.

If the lamps are run on the pumps, any that show blue lights during the testing should be rejected and sent back for re-exhausting; but if they are not run on the pumps, lamps

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for high electromotive force will occasionally show blue lights, which disappear at once and may be disregarded if the lamps show green phosphorescence on the induction coil.

The whole question of high vacua and the adhesion of air to the glass demands thorough investigation. Bunsen is of opinion that carbon dioxide is dissolved by the film of water on the surface of the glass, and that, though solution of carbon dioxide in water at ordinary pressures does not act on glass, still the capillary attraction exerts such enormous pressure that a sufficiently strong solution is made to act on the glass, forming carbonate of soda.

The writer hopes to be able to carry out some further experiments on high vacua within the year, and if they prove worth it, to publish any results that may throw light on the difficult question.

SOUTH KENSINGTON.

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT.

The following were the questions set at the recent examination in Subject IX., Magnetism and Electricity; Examiners, Prof. G. Carey Foster, F.R.S., and Prof. A. W. Rücker, F.R.S.

General Instructions.—(If the rules are not attended to the paper will be cancelled.)—You may take the elementary, or the advanced, or the honours paper, but you must confine yourself to one of them. Put the number of the question before your answer. You are to confine your answers strictly to the questions proposed. Your name is not given to the examiners, and you are forbidden to write to them about your answers. The examination in this subject lasts for three hours.

First Stage or Elementary Examination.

Instructions.—You are not permitted to attempt more than eight questions. You may select only two in magnetism, three in frictional electricity, and three in voltaic electricity. The value attached to each question is the same.

Magnetism.

1. A small magnet is placed upon a flat cork which floats in a basin of water, and it is fastened to the cork with a little wax. Describe and explain the behaviour of the magnet (1) when under the influence of the earth's magnetism alone, (2) when an artificial steel magnet is brought near to it.

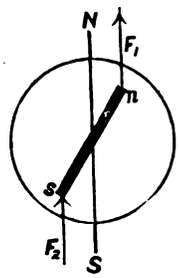

Fig. 1.

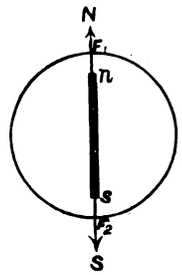

Fig. 2.

Answer.—When under the influence of the earth's magnetism alone the cork will come to rest with the needle in the direction of the magnetic meridian and with its north-seeking pole pointing northwards, but it will have no tendency to move bodily in any direction.

The reason of this is that the forces F_1, F_2, exerted by the earth's magnetic field on the two poles of the needle in any position, as n s, Fig. 1, are equal in magnitude, and act in opposite directions parallel to the magnetic meridian, thus forming a couple tending to turn the needle about its centre until it comes into the magnetic meridian, as in Fig. 2, when it will remain at rest, since the forces F_1 and F_2 are then oppositely directed in the same straight line, and therefore have no resultant effect.

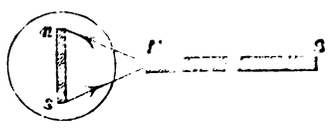

Fig. 3.

When a steel magnet is brought near to the floating needle, it will overcome the influence of the earth's magnetism, and its nearer pole (N in Fig. 3) will exert a stronger force than its more remote pole, will repel the similar pole of the needle and attract

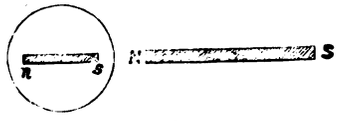

Fig. 4.

the dissimilar pole, causing it to turn with its dissimilar pole towards the near pole of the magnet, as in Fig. 4, and then the dissimilar poles being nearer than the similar poles, the attraction will be greater than the repulsion, so that the cork will move bodily towards the magnet.

2. A compass needle and a straight strip of soft iron of the same length as the compass needle are fastened together so as to be in contact with each other at both ends. Will the force which tends to make the combination point north and south be the same as that which would act on the compass needle alone? Give reasons for your answer.

Answer. The compass needle N S (Fig. 5) will act inductively on the iron, magnetising it oppositely as shown in the diagram, and

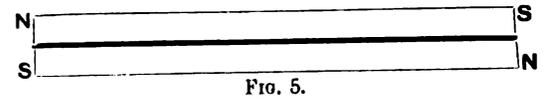

Fig. 5.

the earth's magnetism will act oppositely upon the adjacent poles of the compass needle and the bar of iron, but more strongly upon the compass needle, since the induced magnetism of the bar will be less than that of the compass needle. Therefore the forces acting on the ends of the combination, being equal to the sums of the forces acting on the two component parts, will be in the same directions, but smaller in amount, than those originally acting on the compass needle.

3. How would you construct an astatic needle out of a uniformly magnetised strip of watch spring, which you are allowed to bend or break as you please?

Answer. Break the watch spring in the centre, so forming two magnets of equal strength. Fasten them rigidly together by means

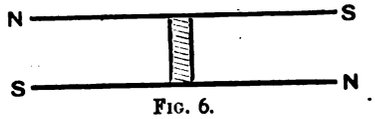

Fig. 6.

of some non-magnetic substance, with their axes parallel, and their poles in opposite directions, as shown in Fig. 6.

Remarks. We should note that such a combination, if it could be made exactly as stated, would form an absolutely astatic needle, viz., one on which the earth's magnetism would have no effect whatever, so that if it were to be used as a galvanometer needle, it would either have to be suspended by two threads close together (bifilar suspension), or by a fine wire or glass fibre, whose torsion would be sufficient to give it a definite direction.

In practice, however, it would be very difficult to ensure such absolute equality in the two portions, and even if once attained, the slightest change in the magnetisation of one of the strips relatively to that of the other would destroy the absolute astatic property of the combination, and enable the earth's magnetism to exert a slight directive force upon it, setting it in the normal direction of the stronger strip.

4. If a compass were carried round the equator, would it point in the same direction at all places? If not, state, as nearly as you can, what changes would be observed in its behaviour during the journey.

Answer.—It would not point in the same direction at all places. Starting from the east of South America and travelling eastwards, it would have a westerly declination, increasing from zero to a maximum, and diminishing again to zero at a point in the Indian Ocean; and continuing our journey round the equator it would have an easterly declination, increasing as before from zero to a maximum, and diminishing again to zero on returning to the starting point. The points of maximum declination would be about midway between the points of no declination.

(To be continued.)

A Simple Method of Multiple Writing by Electricity.—Some few years ago, at a time when there was a rage for all kinds of apparatus for multiplying facsimile copies of handwriting, it will be remembered that Edison brought out an ingenious "electric pen," in which a small needle darting to and fro at great speed made minute perforations in the paper, the printing being effected by an inked roller which was run over the perforated paper like a stencil plate. The movement of the needle was produced by means of a tiny magneto-motor mounted upon the style and driven by a couple of bichromate cells. The cells had, however, to be of large size, the motor requiring a good deal of current. Moreover, it was impossible to write very fast with the pen in the first instance, owing to its weight and the necessity for holding it in a vertical position. Recently, M. Garel has succeeded in obtaining similar results by more simple means. He writes with an ordinary black lead pencil upon very thin paper, which is laid upon a smooth carbon block. The lead of the pencil is connected to one terminal of a small induction coil, and the carbon block to the other terminal. A spark then follows the pencil point, and the paper can be used as a stencil. We do not know what amount of battery power or what size coil is actually required in this process, but the experiment is an interesting one, even if not of much practical value.

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PROGRESS OF ELECTRIC RAILWAYS.

The comparative statistics which appeared in our columns a fortnight ago relating to ELECTRIC RAILWAYS now actually at work in Europe and America enable us to review with some degree of confidence the progress which that system of locomotion has made during the past two or three years. The tabulated statement furnished by Mr. COMMERFORD MARTIN to the American Institute of Electrical-Engineers carries us back to the year 1881; but in reality the lines then attempted or constructed were merely experimental and tentative; and it was not till 1884-5 that serious efforts were made to develop electric railroads on the commercial basis, which those earlier experiments had by that time proved to be possible. Taking, then, the middle of 1884 as the new departure, the number of lines constructed down to the beginning of the present year is very remarkable and highly encouraging. Mr. MARTIN'S table does not profess to be in all respects exact; and in regard to some undertakings of the kind referred to, it is by no means complete. But it would appear that the first permanent electrical railroad was laid down at Lichterfelde, Berlin, in 1881, over a distance of 1½ miles, and that it has been carrying passengers at the rate of 100,000 annually ever since. At Zankerode, in the same country, a shorter line, on the overhead conductor principle, was constructed for mining purposes in the following year, and is said to be carrying about 300 tons of material daily. In the year following, the well known line at Portrush, six miles in length, and the one mile railroad on the Brighton beach came into operation, the former being worked primarily by water-power, and a third rail for conductor; the latter by a gas engine, the ordinary rail track acting as conductor.

Upon these beginnings it may be said that all the later electrical railroads and tramways have been modelled. The success of the Brighton line was not less than that of the line at Berlin; and this was soon followed by a perhaps still more profitable undertaking at Blackpool, which is said to have carried a million passengers in little over two years. The conduit system for the conductor is, as our readers are aware, employed on the two-mile line at Blackpool; and when we have said this we think we have exhausted all the elements of novelty introduced down to the beginning of last year, when storage batteries were tried for some time on the Hamburg tram lines. The experiment at Hamburg has been followed at Brussels in the present year; but whether or not the general result of this new departure be as hopeful as Herr HUBER would have us believe, it is clear that the storage system has not yet found favour in America, where the methods which have proved so successful in England and Ireland have been closely copied. Nevertheless, considerable interest is being taken at the present time in America in the use of secondary batteries for traction purposes, and several lines will shortly adopt this principle. Electrical locomotion in the States, however, did not make a start till 1885; but in the two years since then there have been at least a dozen electric railroads constructed, some of them of considerable extent—that at Montgomery, Ala., being 11 miles long. Most of these lines are for passenger traffic, and the yearly freight ranges from 200,000 to 500,000 persons. It is noteworthy, however, that on the longest line just alluded to extra cars have been added to the two with which the line started in 1885-6, and it is now carrying passengers at the rate 1,000,000 annually. As a rule the prime power is supplied by steam, but in several instances the motors are operated from electric lighting stations, which thus do duty for both illumination and locomotion purposes.

Here it will be observed the Americans are ahead of us. Probably this may be attributed to the price of gas being higher in the States than in England. But we call attention to the fact in order to point out that the electrical power required here for locomotion might in some cases serve for the purpose of illumination, just as in the States the electric light plant has been utilised for supplying locomotive power. There are two or three projects on foot just now for fresh underground railways in the metropolis. It would be an immense boon to travellers by these subterranean tunnels if electricity were employed, both for the motive power and for lighting. Either the tunnels themselves or the cars ought certainly to be lit by arc or incandescent lamps; and this could be most economically effected if the trains were also worked electrically. Moreover, it is not difficult to see how easily this arrangement would lend itself to the lighting of the district covered, or rather undermined, by the proposed railways. The conductors in the tunnels might be tapped at suitable intervals, and a system of electric lighting established above ground, which would greatly help to pay the cost of the electric locomotion below. It is to be hoped that electrical engineers are alive to these facts, and that some strenuous efforts may be made without delay to induce the promoters of the new underground railroads, all of which are far away beyond the reach of daylight, to consider the electrical possibilities here suggested.

On the economical side of the question we need not particu-

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larly dwell. The figures supplied both by Mr. MARTIN in regard to electric railroads worked on the American and English plans, and by Herr HUBER, relative to the cost when storage batteries are employed, tend to show that for short lines, such as we have just been referring to, electricity will favourably compare with steam power. By utilising the former for illumination as well it would be cheaper than steam, and the cost of maintenance considerably lower. That this has been proved to the satisfaction of American financiers is evident from the fact that the striking success of the lines which have begun working during the past twelve or eighteen months has resulted in the commencement of a great number of additional lines. Nearly a score of these are actually in process of construction; and companies have already been formed for similar undertakings at about forty other places in different parts of the States. Herr HUBER is satisfied that even storage batteries are much cheaper than horse-power for tramway lines; but the facts just cited are conclusive evidence that in America certainly electricity is held to be cheaper than either horse or steam power, at all events on lines for the working of which electricity is peculiarly adapted.

CORRESPONDENCE.

PROF. FORBES'S MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I ask why this dynamo is so persistently called non or uni-polar? It has two poles as much as any other machine, and, with all respect to Prof. Forbes, it would be more correct, and shorter, to call it simply "Forbes's dynamo." The notable feature of this machine lies in the fact that it produces current by aid of a symmetrical field, and not by any special polar properties. Mr. Scattergood, in his letter of the 2nd inst., says, "The rotation of a cylindrical bar magnet about its axis does not induce a current in a fixed metallic circuit placed in its field, because the number of lines of force which pass through the circuit are unaltered by the rotation of the magnet, the field being symmetrical about the axis;" whereas Mr. Voice, in a following letter, shows that a machine can be made to produce current under such conditions.

Mr. Scattergood, in the quotation given above, has negatively stated the law of induction as commonly understood, and I think it is here that the difficulty has risen, inasmuch as this law is not sufficiently definite. In view of the facts before us it would seem that to produce current it is not absolutely necessary that the conductor at any section should traverse or be traversed by a varying field, and moreover that current can be generated if any two or more consecutive sections be passed through such portions of the field as shall have relative inductive properties, although each section may in itself traverse a uniform field. Under such conditions a difference of potential would be established at two points along the path of the conductor with a resulting current.

On reference to the machine illustrated by Mr. Voice it will be seen that the fact of the wires leading to the galvanometer being cut by the lines of force would not account for the current, as an equal and opposing E.M.F. would be set up in each; but when we consider that the collector at the centre (although traversed by a symmetrical field) is under greater inductive influence than that at the end, it is easy to divine the cause of the current. I am afraid I do not agree with Mr. Voice's theory that a magnetic field would not revolve with the magnet. It is undoubtedly true that in an ordinary dynamo current is produced by the reaction of a condition that itself is instrumental in maintaining; but I do not think he has sufficient grounds for establishing a law contrary to all analogy, and I am of opinion that the field and the conductor transmitting the current, or the magnet and its field, are as intimately connected with each other as the atmosphere and earth of our terrestrial system, and would with as much reason revolve together.—Yours, &c., N. G. THOMPSON.

4, Queen Victoria-street, July 14th, 1887.

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have noted with some interest the correspondence lately published in your columns on the above subject. There can be little doubt that many estimates from time to time tendered for electric lighting work mention such a low price that it is impossible the work can be creditably carried out for that sum without loss to the contractors. Now the question of loss or otherwise is a matter for the contractor himself to decide, providing he always carries out his work well whatever it may cost him; but it is particularly to be noted that those who habitually underestimate are those who are least able to bear the loss involved, and therefore their work is badly done. Now, Sir, though we can afford to look on at a firm of contractors making a loss and yet doing their work well, we cannot permit them to do their work badly and continue to produce the bad impression about electric lighting that unfortunately does exist on this account. It is difficult to see how the case can be well met, for even if the trade could manage to arrange a minimum price for each different class of work, those who do their work badly would probably continue to do so and make a large profit.

Probably, therefore, the consulting engineer is the only one who can achieve a radical change, and there is little doubt he would be largely employed if he would consent to accept a moderate fee for small works. Perhaps some of these gentlemen will give us their views on the subject.

If a consulting engineer were always employed the "cheap work gentlemen" would rapidly disappear from off the face of the earth.—Yours, &c., MANVILLE AND MADGEN,

Managing Directors United Electrical Engineering Company.

36, Albert Embankment, London, S.E, July 13, 1887.

THE ZIPERNOWSKI-DERI TRANSFORMERS AT ANTWERP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read with much interest in your issue of the 1st inst. the report of your Brussels correspondent relating to the experiments in electric lighting with transformers carried out by the Société Industrielle d'Electricité of Brussels, and we only beg to add that the dynamos and transformers for that installation have been supplied by our company, the Société Industrielle having bought them from us with the right of using them in combination with the Zipernowsky-Déri system of distributing electricity.—Yours, &c.,

Buda-Pesth, 7th July, 1887. GANZ AND CO.

A SUGGESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Though there is probably some mistake in the daily journal account of the electric launch to which you refer in this week's "Notes," I have often thought that sailing vessels might be provided with some sort of turbine, which could be used to store electricity in a good wind, so as to drive the vessel by means of an auxiliary screw in a calm.

I should be glad if you could find space for this idea in your pages.—Yours, &c., E. CHURCHILL.

Northwich, July 9, 1887.

THE JUBILEE BEACON LIGHTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The brilliant white glare seen from the Titterstone Clee Hills, Shropshire, with reference to which you have a note

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in the current number of your journal, doubtless came from three arc lamps which were erected on the top of the church tower (St. Leonard's), Bridgnorth, on the Jubilee night. A pole about 20ft. high was erected on the top of the tower—which stands on the highest point of the hill on which the town is built—and the lamps suspended from three short brackets in the form of a triangle. They were about 3,000 candle-power each, and were Phillips and Harrison's patent, manufactured by Elwell Parker, of Wolverhampton, who also supplied the dynamo, an 8-unit nominal, running under speed. The engine was a Marshall portable, in not very good condition, and required considerable coaxing to induce it to run steadily and not jump about the yard. A very satisfactory run was, however, secured.

On the following Tuesday, Wednesday, and Thursday Bridgnorth held its own Jubilee celebrations, and the lamps, with two additional ones, were erected in the High-street. The lighting was carried out by Councillor Whitefoot and Mr. C. J. Turnbull, of High-street, Bridgnorth, under my supervision. Bridgnorth lies about north-west by north of Titterstone Clee Hills,—Yours, &c., W. B. SAYERS.

Edgbaston, Birmingham.

By a later post we have received the following additional note from Mr. Sayers:—

"On referring to the map I see I am in error in supposing that Titterstone Clee Hills lie about south-east by south of Bridgnorth; they lie about south-west by south, so that Bridgnorth is north-east by north of Titterstone Clee Hills. Nevertheless, I am confident that the Bridgnorth lights or their whereabouts, if something intervenes, must have been easily discernible from Titterstone Clee Hills, and think it probable that a mistake was made as to the direction in which the glare appeared."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I cannot lay claim to the origin of the interesting arc light which was visible on Jubilee night in the direction explained in this day's *Electrician*; but on the night in question I had a Crompton lamp on the top of my house, which stands high on Cannock Chase. The current was supplied from "E.P.S. accumulators," which I have used for house lighting for about 18 months, with perfect success.—Yours, &c.,

F. D. BUMSTED.

Hednesford, Staffs., 8th July, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 8th you had a note asking where a certain light proceeded from. Messrs. Storey Bros., Lancaster, had a large search light on the top of a high chimney on the night of Jubilee and three following nights. You do not say whether the light seen was a fixed or revolving one. Ours was not directed to any one place for more than 30 minutes [? seconds] at a time. Do you think it possible that it could have been seen at so great a distance?—Yours, &c., J. PARKINSON.

White Cross Mills, Lancaster, July 12, 1887.

[Lancaster is about 140 miles from the Clee Hill, and is also several points round to the north of the direction in which the light was seen, so it is scarcely probable that this is the light in question.—ED. *E.*]

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XLIII.

BY OLIVER HEAVISIDE.

Reflection due to any terminal resistance, and establishment of the steady state. Insulation. Reservational remarks. Effect of varying the Inductance. Maximum Current.

If there be a resistance R_1 at the end B of a non-distortional circuit, its presence imposes the condition $V = R_1C$ at B permanently. If, then, there be a wave travelling towards B, we find the nature of the reflected wave from B by applying the above terminal condition to the actual V and C which are the sum of V_1, V_2 the potential-differences in corresponding portions of the incident and reflected waves, and of C_1, C_2 the currents in these portions. Thus we have

$$V_1 = Lv C_1;\ V_2 = -Lv C_2;\ V_1 + V_2 = V;\ C_1 + C_2 = C;\ V = R_1 C;$$

to represent the full connections. From these we find

$$V_2/V_1 = (R_1 - Lv)(R_1 + Lv)^{-1} = \rho_1 \text{ say}, \quad . \quad (26d)$$

giving the reflected in terms of the incident wave. This ratio is positive if R_1 be greater and negative if it be less than the critical Lv. In the former case there is reversal of current, in the latter of electrification, produced by the reflection. The three most striking cases are when $R_1 = 0$, ∞, or Lv, *i.e.* short-circuit, insulation, and the critical resistance of complete absorption, making $\rho_1 = -1, +1$, or zero. There is partial absorption and loss of energy whenever R_1 is finite, but none whatever in the two extreme cases. The loss of energy is accounted for by the Joule heat in the terminal resistance.

In a similar manner, if there be a resistance R_0 at the near end A, the transforming factor is

$$\rho_0 = (R_0 - Lv)(R_0 + Lv)^{-1} \quad . \quad . \quad . \quad (27d)$$

If there be given an isolated charge moving towards B at a certain time, it will, after reflection at B, be replaced by another charge moving towards A, which may be of the same or of the opposite kind, according as the reflecting resistance is greater or less than the critical. On arrival at A it is transformed into a third charge moving towards B, and so on. There is the usual attenuation ρ in each journey, where $\rho = \epsilon^{-Rl/Lv}$. If there be complete insulation at both ends, there is no other attenuation than this due to the circuit; and similarly, if the ends be short-circuited; but in all other cases it has to be remembered that the act of reflection attenuates, besides causing a reversal of either the electrification or the current.

The complete history of the establishment of the steady state due to a steady impressed force at A is now expressible in terms of the three constants ρ_0, ρ, and ρ_1; with, of course, x the distance, t the time, and e the impressed force. There is first the positive wave

$$V_1 = \tfrac{1}{2}e(1 - \rho_0)\epsilon^{-Rx/Lv}, \quad . \quad . \quad . \quad . \quad (28d)$$

due, as mentioned in the last section, to the union of the initial positive wave of half strength and of the positive wave which is the reflection of the initial negative wave of half strength, which latter is rendered visible by shifting the seat of e towards B. The solution (28*d*) applies to all values of x less than vt, which is the extreme distance reached by the wave at time t after starting. On arrival at B we have to introduce the transforming factor ρ_1 above defined. The reflected wave is therefore

$$V_2 = \tfrac{1}{2}e(1 - \rho_0)\rho^2\rho_1 \cdot \epsilon^{Rx/Lv}, \quad . \quad . \quad . \quad (29d)$$

which is to be superimposed on the former wave to obtain the real state during the second journey, from B to A. The region over which V_2 extends grows at a uniform rate with the time, from B to A. On arrival of V_2 at A we must introduce the transforming factor ρ_0 to obtain the third wave, which is

$$V_3 = \tfrac{1}{2}e(1 - \rho_0)\rho^2\rho_1\rho_0 \cdot \epsilon^{-Rx/Lv}; \quad . \quad . \quad . \quad (30d)$$

this reaches B at time $t = 3l/v$, when the fourth wave commences, which is to be found by introducing the transforming factor ρ_1; thus

$$V_4 = \tfrac{1}{2}e(1 - \rho_0)\rho^4\rho_1^2\rho_0 \cdot \epsilon^{Rx/Lv}. \quad . \quad . \quad . \quad (31d)$$

It is unnecessary to proceed further, as it would only produce repetitions. The positive waves V_1, V_3, &c., have the common ratio $\rho^2\rho_1\rho_0$, and are otherwise similar. Their sum is therefore

$$\tfrac{1}{2}e(1 - \rho_0)(1 - \rho^2\rho_1\rho_0)^{-1} \cdot \epsilon^{-Rx/Lv}. \quad . \quad . \quad (32d)$$

Similarly the sum of the negative waves is

$$\tfrac{1}{2}e(1 - \rho_0)\rho^2\rho_1(1 - \rho^2\rho_1\rho_0) \cdot \epsilon^{Rx/Lv}. \quad . \quad . \quad (33d)$$

The final state of V is therefore expressed by the sum of (32*d*) and (33*d*). In all the positive waves the current is from A to B, and in the negative from B to A; hence the

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excess of (32d) over (33d) divided by Lv expresses the final state of current.

The solution of the above problem by means of Fourier series is extremely difficult. It expresses the whole history of the variable period by a single formula. But this exceedingly remarkable property of comprehensiveness, which is also possessed by an indefinite number of other kinds of series, has its disadvantages. The analysis of the formula into its finite representatives, so that during one period of time it shall represent (28d), then in another period represent the sum of (28d) and (29d), and so on, *ad. inf.*, is trying work. (I gave it up as a case of "sour grapes.") And the getting of the formula itself is not child's play. Considering this, and also the fact that a large number of other cases besides the above can be fully solved by common algebra (with a little common sense added), the importance of a full study of the non-distortional system will I think be readily admitted by all who are dissatisfied with the views so forcibly enunciated by the eminent scienticulist on the subject of the speed of the current at the time of the last explosion. The important thing is to let in the daylight on a subject which it was difficult to believe could ever be freed from mathematical complications. And on the admission of daylight, the ghosts in the cupboard under the stairs vanish.

There is a rather important remark to be made concerning the two extremes, $R_1 = 0$ and $R_1 = \infty$, at the end of the line, in the above solution. Although described as shortcircuiting and insulation, they do not really represent the state of things existent when we actually terminate a long circuit of two parallel wires by a thick crosswire (the shortcircuit) or leave the ends disconnected in the air. Every theory that ever was made is more or less a paper theory; we must simplify the real conditions to make a theory workable. Now a theory may very closely represent reality (when pursued into numerical detail) through a wide range, and yet go quite wrong at extremes. The justification for making the constants of the circuit independent of its length is that the length is an enormous multiple of the distance between the wires. But if we terminate the circuit somewhere it is no longer true that the permittance and the inductance per unit length are constants, near and at the termination. The theory, to be correct, must wholly change its nature, as may be seen at once on thinking of the changed nature of the electromagnetic field as the termination is reached. Now our theory says that when the circuit is insulated at B, every charge arriving there is at once sent back again unchanged; and that during the period of reflection, the potential difference is doubled and the current annulled. The doubling of the potential difference is obviously due to there being a double charge with the same assumed permittance. But the permittance is not the same, nor anything like the same, at the termination as it is far away from it. The theory therefore wholly fails to represent the case of insulation, so far as the potential difference at the termination is concerned, though there does not seem to be any reason to suppose that this will affect matters elsewhere; for when the reflected wave gets away from the termination, the old state of things is restored. There is a similar want of correspondence between the theory and reality when we make a real shortcircuit, which we have supposed to be represented by $R_1 = 0$.

Now the question may suggest itself: Since this failure is due to the assumption that the permittance and inductance continue constants right up to the termination, and this assumption being made in all cases, may there not also be a failure when R_1 is finite? The following reasoning will show that this is not to be expected. For if the terminal resistance (although it may be small) yet be equal to that of a considerable length of the circuit, the influence of this resistance on the course of events must be much greater than that due to the changed nature of the circuit near its end. We therefore swamp the terminal corrections, which become so important themselves when the terminal resistance is quite negligible.

The general principle that may be recognised is this. If the transfer of energy between the circuit and the terminal apparatus (of any kind) be of sensible amount, we may wholly disregard the fact that the circuit changes its nature as the termination is approached. But should it be insensible, then we fail to represent matters correctly at and near the termination.

Again, if the ends of the circuit, supposed insulated, be brought sufficiently close together, there may be a spark or disruptive discharge there when a charge arrives, involving a loss of energy and attenuation. It is scarcely necessary to remark that effects of this kind have no place in the theory.

In the same connection it may be remarked that when we are following the history of an isolated charge, which may, in the theory, be confined to the shortest piece of the circuit imaginable, we should really spread it over a length which is several times as big as the distance between the two wires. This is to make the element of length have the same properties as a great length. Similar assumptions are made (though seldom if ever mentioned) in most theories in mathematical physics. An element of volume, for instance, must be large enough to contain such an immense number of molecules as to impart to it the properties of the mass.

Returning now to the study of the properties of the circuit, let us examine the effect of varying the constants. For simplicity, insert the critical resistance at B, and let there be none at A, where the impressed force is. The current at B is then

$$C_B = (e/Lv)\epsilon^{-Rl/Lv} = (e/Rl)y\epsilon^{-y}, \quad . \quad . \quad (34d)$$

if $y = Rl/Lv$. The value of e to be taken in the formula at a given moment should be that at A at the time l/v earlier. Now, with the resistance of the circuit kept constant, vary y to make the current a maximum. We require $y = 1$, or the critical resistance should equal the resistance of the circuit (without leakage). It then also equals the insulation resistance $(Kl)^{-1}$. If the resistance at A be any constant multiple of Lv, we shall have the same property $y = 1$ to get maximum current. [But should the resistance at A be kept constant, we shall have $y^2(R_0/Rl) + y = 1$, which it is unnecessary to discuss.] The received current is therefore

$$C_B = e(2{\cdot}718Rl)^{-1}, \quad . \quad . \quad . \quad . \quad (35d)$$

when no resistance at A; and if there be resistance there of amount zLv, we must divide the right side of (35d) by $(1 + z)$ to obtain the current at B. Thus the result is the same as if the circuit were a mere resistance whose value is a small multiple of the true resistance, with abolition of the leakage, permittance and inductance, but with a retardation of amount l/v. This is not the electrostatic retardation, of course; it merely means the interval of time that elapses between sending and receiving, whereas electrostatic retardation, as formerly understood, is quite another thing. Neither is it the speed of the current; that is v. But singularly enough, the value of the electrostatic time-constant RSl^2 is now l/v itself, proportional to the first power of the length, and inversely proportional to the speed of the current.

Example.—1,200 kilometres at 2 ohms per kilom. Lv should be 2,400. If it be an air circuit, of copper, with v practically = 30 ohms (the formulæ for permittance, inductance, &c., will be given later), we require $L = 80$. This is much too great. The inductance must be artificially increased, if we are to have so little attenuation as above on a circuit of that length. Or the resistance may be reduced. If 1 ohm per kilom., $L = 40$ is wanted. If $\frac{1}{2}$ ohm per kilom., $L = 20$.

The shorter the circuit the smaller is the value of L needed to get the maximum current, and the longer the circuit the greater L should be. If L could be made large enough, without altering the resistance, the circuit could be of any length we pleased. The lower the resistance of the circuit, the less leakage is needed to prevent distortion, and the less attenuation there is. The higher the resistance, the more leakage is needed, and the greater is the attenuation. We see by inspection of (34d) that without varying either the resistance or the permittance, but solely by increasing L (remembering that $Lv = (L/S)^{\frac{1}{2}}$), we could make Atlantic fast-speed telegraphy possible, with little attenuation and distortion. But the speed of the current would be very low. This I shall return to in connection with the sinusoidal solution.

(To be continued.)

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WHAT IS ELECTRICITY?*

BY TOWNSEND WOLCOTT.

It is a common statement that energy can neither be created nor annihilated, and that the total energy in the universe is a determinate quantity. The first part of this statement, although true, is not in itself of vital importance, while the latter part is not true. It is perfectly true that neither time nor space can be created nor annihilated, and yet nobody attaches special importance to this fact, or says anything about the conservation of time or space, and certainly nobody ever tried to prove as a corollary that the total amount of time or space in the universe is a determinate quantity.

The true value of this principle of the conservation of energy is, that it is the expression of the quantitative relations of phenomena. Nearly all, if not all, phenomena consisting of change, or succession of events in time, are referred to force; now we find that all measurable forces have a definite quantitative relation to each other (the correlation of forces), such that the disappearance of one kind of activity, change of position, &c., of material bodies cannot take place without the appearance of an equivalent amount of some other form or forms of activity, &c. This it is that makes the conservation of energy the keystone of modern science. It is the modern equivalent for the old cause and effect.

Potential energy may always be expressed as the line integral of a force. When the force follows the law of inverse squares, as in gravity, electric and magnetic attraction, the integral is finite even when the upper limit of integration is infinite, providing the lower limit is finite; but if the lower limit is zero the integral is always infinite, and therefore the potential energy (in case of attraction but not of repulsion) of a finite system is infinite. If we have a system of attracting bodies, say, gravitating masses, this infinite value will represent what may be called the total potential energy of the system, but the bodies having come into actual contact, if we suppose them incompressible, have parted with all their available potential energy, the other part corresponding to the dissipated energy in the theory of heat.

Now, this available energy where the bodies vary in size, shape, density, &c., is different for every final arrangement, as the closeness of final contact would depend on this; also the arrangement which brought the denser bodies nearer the common centre of gravity would, other things being equal, give the greater value to this available energy. As the order of approach of the bodies may be changed without altering the amount of energy, we must conclude that the latter is either infinite or indeterminate, according to which measure of energy we adopt. Maxwell states that "the existence of a potential function in the field near an electric current is not a self-evident result of the principle of the conservation of energy," as the potential has an infinite number of values differing by $4\pi i$, so that an infinite amount of work may be done on a magnetic pole which is carried round the conductor an indefinite number of times. The work, however, is always a determinate quantity when the limits of integration are finite, as in the previous case. I consider the cases somewhat analogous. The kinetic energy of a moving mass is $\frac{mv^2}{2}$, and we sometimes see it stated that this energy resides in the body. But as the velocity of a body is merely relative, this kinetic energy will have a different value for every other moving body with which we compare the given one.

If two bodies collide, they will, in coming to a common velocity, convert all their available energy (available relative to each other) into some other form, and if we regard some third body as a standard of reference, there will still be a quantity of energy dissipated, the amount, of course, being different for each different body taken as a standard. The reason why the idea of the dissipation of energy has assumed such importance in the theory of heat is that the energy of a hot body is referred to a so called absolute zero of temperature; but this being below the temperature of interstellar space, so far as we know it, we can no more reach it experimentally than we can the absolute zero of contraction mentioned above.

Prof. Dolbear, in his reply to Mr. Carl Hering on this subject, speaks of energy as an objective condition. Here is just where I would differ with him.

Energy is certainly an abstract concept, a class-designation for a variety of forms, and we in these times believe in the philosophy of Aristotle rather than that of Plato. Or to come down to later times, Kant considers time and space as subjective impressions, and it is in this category that I would place energy also, from its interchangeability with the others as a fundamental unit. To assist us in completely freeing our minds from absolute notions, let us consider a remark made by De Morgan, in an article on the "Calculus of Functions," namely, that we are accustomed to regard quantity as being generated by the successive additions of *equal* increments; thus an hour is considered as the sum of sixty equal parts called minutes, a minute of 60 seconds, and a second may be considered as composed of an indefinite number of smaller equal parts. This is the most natural process for the human mind, but conceive of a mind to which the natural process would be to consider quantity as generated by the successive addition of *percentage* increments; to such a mind what to us is the theory of logarithms would be the common arithmetic, and what we express as $a + b$ would be a difficult operation. In fact, it was by employing this conception of kind that Napier discovered logarithms and not by the extended conception of exponents, as is sometimes supposed. I have given De Morgan's meaning from memory and do not quote his words.

Let us apply a similar method of analysis to the theory of fundamental units. Maxwell gives length, time, and mass as the three fundamental units on which all others are made to depend. These units, however, are fundamental only in a relative sense, as we may take other magnitudes as fundamental, and make length, time, and mass depend on these.

The most general statement of the theory is that three independent units having been established; all other physical units may be made to depend on these, reducing the whole to a connected system.

Space, or the more specialised conception, length and time, are among the earliest abstract notions acquired by the human mind, but with mass the case is different. It is only since the general adoption of the principle of the conservation of energy that the conception of mass has attained its present distinct individuality, it being in fact a more refined substitute for the "weight" of the older science. The *vis viva* of Newton (which was equal to twice the kinetic energy) was not mv^2 but $\frac{wv^2}{g}$, w being the weight and g the force of gravity. Energy, then, has at least an equal title with mass to the position of fundamental unit, on the ground of being in the natural order of our mental processes. We may therefore substitute energy for mass, and using E as its symbol and Maxwell's notation, we have the dimensions of the unit of mass $[E\,T^2\,L^{-2}]$; and in fact the only definition of mass we have which is at all characteristic contains this formula by implication.

We may define mass as that which possesses weight or attraction for other masses; but it is only when we add that a mass moving with a given velocity is capable of doing a definite amount of work that we obtain any distinctive idea of mass. Instead, however, of substituting energy for mass we might substitute it for either length or time, and conceive of a mind, according to De Morgan's method, to which this would be the natural order.

Again, we always think of a velocity as the ratio of a distance to a time, but there is no reason why we should not regard velocity as an independent magnitude, and a time the ratio of distance to velocity; or a distance, as the product of a velocity and a time, according to which substitution is made. Now, according to a statement of Prof. Dolbear, that energy has an objective existence as well as matter, of which the measure is usually considered mass, and ether, which as yet has no measure, we may construct a system of fundamental units of which one or two are the measures of objective realities, while the remaining two, or one, are merely subjec-

* Abstract of a paper read before the New York Electrical Society.

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tive impressions. If the ether had an independent measure we might take mass, energy and ether as fundamental units, making all three objective, or, adopting the vortex theory, and discarding mass, we must take in again one of the merely subjective magnitudes to fill its place. This proposition, to my mind, is a good deal like saying that one of the dimensions of space has an objective existence while the others have not. Preceding the discovery of the conservation of energy was the discovery of the indestructibility of matter, and in some of the older works on chemistry it is stated that, while all other attributes of matter are changeable, the absolute weight remains unchanged under all conditions.

As the weight is only determinate under determinate conditions, it has been recommended that conservation of mass should be substituted for indestructibility of matter, mass being considered the only thing which remained unchanged. But is this correct?

All the chemical properties of a body have determinate magnitudes when a sufficient number of conditions are fixed, and the whole method of volumetric chemical analysis is founded on this principle.

I have gone thus at length into the general theory of conservation to show that it does not necessarily apply alone to energy and mass, but that the abstract generalization from any complete series of quantitative relations between measurable magnitudes, not included in these two, is a new conservative principle.

For if it were not a conservative principle then the magnitudes would not always have the same quantitative relations. Conservation is the statement of the uniformity of nature, or, if you prefer the expression, the constancy of natural law. I will add that the conservation of energy is so broad a principle that nothing outside of it is likely to be of very great importance. From this point of view it is no more than we should expect that some one should establish a conservation of electricity, as Prof. Sylvanus P. Thompson seems to have done, nor is it any proof that electricity is matter, as Mr. Carl Hering appears to think. The most direct proof to my mind that electricity is not matter, is the experiment of Maxwell, tried in 1861, to prove that the electric current has no momentum.

The answer to our question depends in a great measure on the definition of electricity. The electrostatic unit of quantity is identical with the unit of electrification, and the electrification of an insulated conductor in equilibrium is all upon the surface; that is, where the conductor ends and the new conductor begins. This quantity of electricity is as definite a physical quantity as any other, as the operations of measurement, addition and subtraction may be *experimentally* performed upon it, which is all that we can do with any physical quantity. We may therefore regard electricity as existing in two dimensions (which, by the way, matter has never been known to do). Still, whether we adopt the theory of action in a distance, or Faraday's theory, mathematically developed by Maxwell, of stress in the dielectric, we cannot ignore the fact that there is a definite distribution of force in the surrounding space, which is investigated in the theory of potential. Let us take the analogy of a shadow. A shadow in ordinary language is a darkened *surface*, but this darkened surface is merely a section of a darkened *region*, and it is this darkened region that is called the shadow in astronomy. The superficial shadow cannot exist without the solid shadow, and, on the other hand, the solid shadow cannot exist without there being a superficial shadow on a properly placed surface. Of course, to us a shadow is a mere negative, the absence of light. But suppose some one to be investigating it, not knowing that it was only a shadow, he might regard the superficial phenomenon as the direct action at a distance of the opaque body, or he might assume an ether with all sorts of convenient properties, and explain matters in that way. But we regard the superficial and solid shadows as merely different phases of the same phenomenon.

The trouble with our question as usually put is, that we define electricity as we have just done, then insist that this is the genuine article, and fundamental in its nature, while all other phenomena which are essentially electrical are merely consequences of this fundamental quantity of electricity, and then we demand, What is electricity? That is to say, which of three or four other things that we allow to have a real existence, viz., matter, energy, &c., is it? I would answer emphatically it is no one of them.

Let us abandon absolute ideas and treat all electrical phenomena as equally fundamental, simply striving to discover their relations to each other, and to other phenomena; then each discovery is a partial answer, and the only kind of an answer we will ever have to our question. As to our present knowledge of the subject, it is as great as of any other subject in natural science. Indeed, Maxwell says in his preface:—"The internal relations of the different branches of the science which we have to study are more numerous and complex than those of any other science hitherto developed."

I have often put the counter-question to my friends, What is heat? The unscientific ones usually say, "Heat? Why anybody knows what heat is; there is no use of such a question!" Or, "Heat is heat;" or, "Heat is the opposite of cold." Those that have read Tyndall reply very glibly that heat is a mode of motion. But Tyndall's book only proves, and indeed only sets out to prove, that heat is a form of energy. We know that electricity, as we define it, is not energy; but we do know what its relation to energy is, which is just as important and characteristic knowledge as we have in the case of heat.

THE UNION ELECTRICAL POWER AND LIGHT COMPANY.

On Wednesday afternoon, at Palace-chambers, Westminster, Prof. George Forbes, F.R.S., delivered an address upon the storage battery to a number of gentlemen, who attended upon the invitation of the Union Company. After a few introductory remarks from the chairman of the company, Prof. Forbes delivered an interesting address, of which the following is an abstract:—All present would remember how great were the expectations which were aroused some few years ago on the advent of the Faure storage cell, and how comparatively meagre was the success which that battery actually attained in practice. He would endeavour to lay before them point by point the causes of the failure of the original Faure cell, indicating at the same time the manner in which these defects had been obviated in the battery of the Union Company. (1) In the first place the mechanical construction of the Faure cell was such as to utterly unfit it for much of the work which secondary batteries were called on to perform. The negative plates consisted of a sheet of lead, against which was laid a paste of the salts of lead, and this paste was retained in position by an envelope of felt. This arrangement was obviously weak, and in practice, after a little time, the slightest jolting caused the paste to peel off from the lead surface, and before long the acid destroyed the felt covering. In the Union cell the negative plates consisted of an absolutely solid mass of lead peroxide, which had no tendency whatever to disintegrate under the action of the acid, and would bear plenty of rough usage. This form of peroxide was the invention of Mr. FitzGerald, and had received the name of lithanode.

(2) In a battery used for locomotive purposes the question of weight was of great importance. In the Faure cell, as already explained, the negative plates were necessarily made with heavy masses of lead to support the litharge. In the Union cell the negative plate consisted solely of the active material, and no lead backing was required, thus effecting a very great saving in weight. He (Prof. Forbes) had at various times tested over a dozen cells of different types, of which there were only one or two on which he had been able to give a favourable report; but of all these the Union cell was by far the best in respect of capacity of discharge for a given weight of material.

(3) The third point in favour of this cell was one of high value, though he did not pretend fully to understand the reason for its existence. It was this. In lithanode cells there was no tendency to the formation of white sulphate. In all other lead batteries with which he was acquainted—even in the cells at present made by the Electrical Power Storage Company, which he would say were excellent cells in many respects—there was an unfortunate tendency to the formation of a salt of lead whose presence prevented the full utilisation of the capacity of the cell. The only method by which the formation of the sulphate can be prevented, and the only conditions under which cells of the E. P. S. type can be worked with full success, is that they are regularly and constantly charged to their fullest capacity. If these cells are allowed to remain at

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rest, after being even partially discharged, sulphating sets in. When the sulphate has once been formed in any quantity, the way of getting rid of it is to charge the cell continuously for a lengthened period of time until all traces of sulphate have disappeared. This, of course, is an expensive process, although it is perfectly effective. The Electrical Power Storage Company consequently recommend their customers never to allow their cells to remain discharged for any length of time. This is, to say the least, a little awkward, if, for instance, an installation in a town or country house is intended to be disused for any portion of the year. As he had already stated, this drawback was entirely absent in the case of the Union cell.

(5) The next point he would refer to was the indestructible character of the electrode or contact plate, consisting of a thin strip of platinum enclosed by celluloid. It was true that the use of this material added somewhat to the first cost of the cell, but the platinum being absolutely unalterable, this part of the outlay was of the character of capital expenditure.

(6) The Union cell might be completely discharged and left in this condition for any length of time without, so far as he had yet been able to discover, any deterioration whatever. He had repeatedly taken partially discharged plates, laid them aside for weeks at a time, and then found them as good as ever. This was a very severe test indeed.

He would proceed to note a few of the minor advantages of the cell. Lithanode plates were admirably adapted for use in primary batteries. At present, for ordinary domestic and telegraphic use, there was no cell so extensively employed as the Leclanché, which in its own field had long remained practically without a rival. He thought, however, that the Leclanché would now have difficulty in maintaining its supremacy as a single-fluid cell against the use of lithanode. A plate of carbon sandwiched between two pieces of lithanode and opposed by a plate of zinc formed in his opinion the best depolarising single-fluid cell yet invented.

In charging a secondary cell there usually occurred towards the end of the process a rise of the back E.M.F. from 2 volts to 2·25, or 2·5 volts. This not only entailed a waste of power, but was also attended by practical inconvenience. In the lithanode cells the spurious E.M.F. did not make its appearance, or only very feebly, which was again a feature of no small value.

Coming to some numerical details, he might state that the capacity of the cell amounted to 39·16 watt hours per kilogramme of active material, or 18 watt hours per lb. of active material, or, again, 31·5 kilogrammes per horse-power hour, including the casing of the cell.

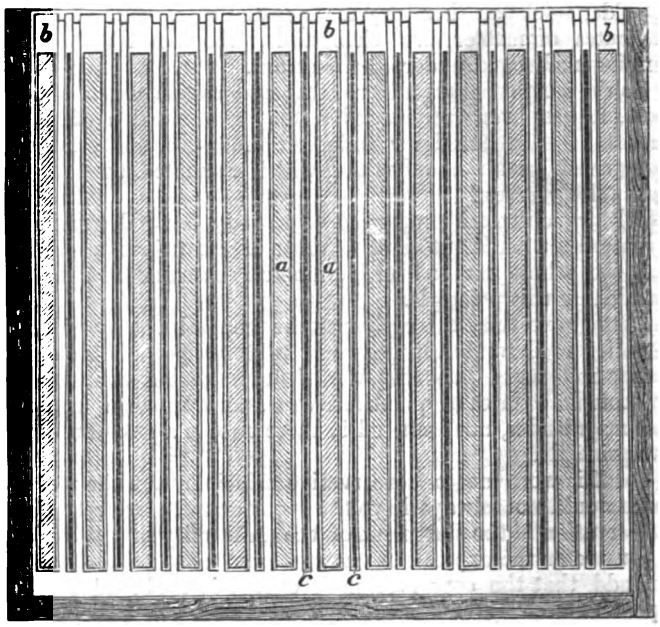
As to the important question of duration, it was impossible as yet to assign any limit to the life of the cells, sufficient time not having yet elapsed. He must therefore confine himself to the statement that cells which had been in use for two years showed no signs of deterioration, but were in all respects as perfect in condition as those of recent manufacture.

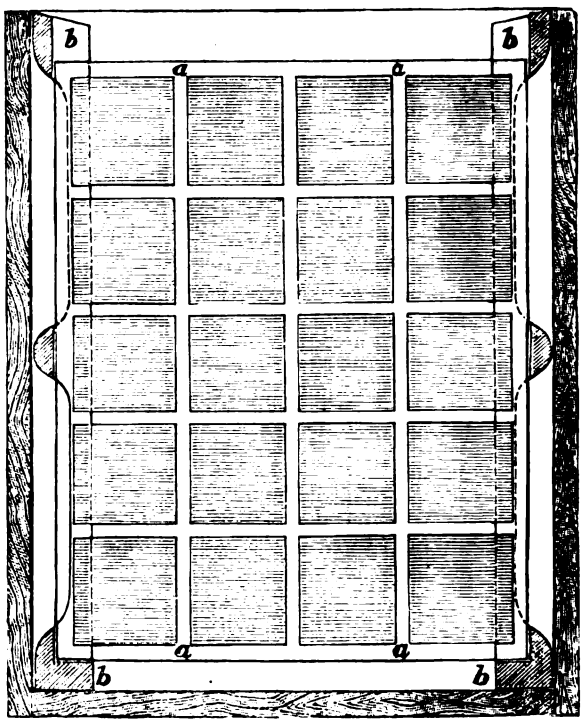
Mr. Henry Lea, of Birmingham, then related some results of his experience with secondary batteries, which he had employed for lighting his own house. With E.P.S. cells he found that, for the reasons which Prof. Forbes had explained, it took upon the whole twice as much engine-running per annum to maintain the installations in proper order as with the cells of the Union Company, which he had now in use. He had subjected these cells to very rigorous treatment, twenty-two times in succession he had half-charged them, and then discharged them as completely as possible. This would, in his experience, have ruined any other cell; but the lithanode plates came out of the trial apparently unharmed, and on testing their capacity he found it quite unaltered. In daily use charging and discharging went on with such perfectly uniform results that he now found it unnecessary to keep any watch upon the cells themselves; a glance at the voltmeter told him when they were fully charged, and the action went forward with as much regularity as if the whole process was a purely mechanical movement instead of being based upon a rather subtle chemical reaction.

Several questions were then asked to which Prof. Forbes replied, and batteries of various power were shown at work driving Immisch motors, lighting lamps, &c.

CORNELIUS SMITH'S STORAGE CELLS.

We illustrate herewith a form of secondary battery which has been introduced by Mr. Cornelius Smith, and we also print below an extract from a report upon the cell made by Mr. L. B. Miller, A.S.T.E. From this it will be seen that the only new feature of the cell consists in the use of thin pieces of lead foil, which are packed edgewise in rectangular holes. The lead slips for the negative plates may either be painted with red lead before introduction, or both plates may be made of plain lead and formed as in the Planté battery. The lead slips are packed somewhat tightly in the first instance, and the expansion produced in charging wedges them firmly in, while all tendency to buckle is obviously avoided. This construction is an undeniable improvement over previous cells of the same general type, but we do not feel called upon to express any opinion as to whether or not the construction is sufficiently novel to steer clear of existing patent rights. We may, however,





In these figures *a* is a grating with rectangular openings, which are filled in the manner described with strips of lead. The plates *a*, when so made and filled up, are inserted into grooves formed in guides *b*, made of vulcanite or other suitable non-conducting material. *c c* are perforated sheets of vulcanite or other material, which, placed between each pair of plates, serve to prevent their circuiting by reason of dirt or scaling.

point out that in the Smith cell contact is made with the grid by every separate lead slip, while in the Elieson type, which it most nearly resembles, contact with the grid is obtained only upon the outer surface of each roll of lead tape, and the current taken off has to traverse all the external convolutions of the roll.

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Some cells of this description have been in use for some time at Whiteley's, in Westbourne-grove, and Mr. Percival, who is in charge of the electrical department there, speaks very highly of their behaviour. We have had also an opportunity of examining some plates which had been in use about three months, and which seemed to be in very good condition, being well formed throughout. Speaking generally, we have been very favourably impressed with the battery, and as against other cells in which a grid is used with the negative plate we are under the impression that this is the best arrangement hitherto devised.

The following is an extract from Mr. Miller's report above referred to :—

The accumulators consisted of 12 cells, with three plates in each, one positive and two negative. The plates consisted of a grid of cast lead about 5½ by 3½, with rectangular spaces an inch square, filled up with thin lead strips placed loosely one on the top of the other. In the cells submitted for testing, which were intended for lighting purposes, the lead strips had been painted with red lead before being packed in, and red lead had also been pressed into the strips from the surface of the plate. The strips made excellent contact with the frame, and although they were packed more tightly than I should consider advisable, on breaking a plate to pieces I could see that the interior surface of the strips was becoming active although the cells were far from being fully "formed." The value of an accumulator depends chiefly on the following points :—

1st. *The efficiency*—*i.e*, the percentage of electricity that can be got out compared with what has been put in.

2nd. *The capacity*—*i e*, the quantity of electricity that can be stored in a cell of a given size and weight.

3rd. *The life* of the cells—*i.e.*, the rate at which they deteriorate with usage.

The Smith and Mensing accumulator comes up to these requirements, in my opinion, to the following extent :—

Efficiency.—The electrical and chemical action in these cells is exactly the same as in others formed of lead plates, and their efficiency is the same, *i.e.*, it ranges between 50—80 per cent. of useful return, depending on the rate of discharge.

Storage Capacity—This depends on the quantity of active material, spongy lead, and lead peroxide there is in the cells. To obtain a large quantity a large surface must be exposed to the action of the current ; but it has been found in practice very difficult to combine this with the necessary amount of mechanical strength in the plates to make them stand ordinary usage in installations. In the accumulators submitted to me this requirement of large surface is very well met, and without in the least weakening the plates. The current is able to penetrate into the spaces between the strips and make the whole of their surface active, the only effect of the resulting expansion being to make the strips fit the space they occupy more tightly and make better contact with the frame. This result is of very great importance as the failure of accumulators is nearly always due to "buckling" and consequent short-circuiting, the buckling being due to the unequal expansion of the two sides of the plate causing it to assume a curved form. I have charged and discharged the new accumulators at about four times the usual rate without them showing the least signs of "buckling."

Life of the Cells—I am convinced the accumulators will give highly satisfactory results in this direction, as two of the worst causes of destruction, "buckling" and falling out of the peroxide, are not likely to occur.

Speaking generally I consider the new accumulator to be a good and sound cell, and one likely to give satisfaction in working.

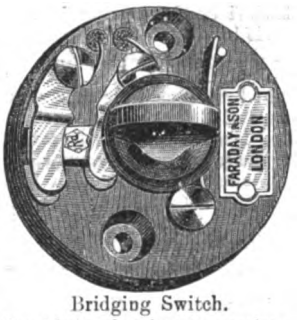
The following details are given as to one particular type of these cells :—

Description of Cells.		Working Rate		Capacity.	External Dimensions.				Weight.
No. of Plates.	Material of Box.	Charge Amps.	Discharge Amps.	Ampere Hours.	Length ins.	Width ins.	Height ins.	Height over all.	Complete with Acid about
13	Vulcanite in Teak or Glass.	30—40	,, to 45	400	9	8	9	10	65lbs.

NEW INCANDESCENT FITTINGS.

A new switch has just been registered and brought out by Messrs. Faraday and Son, of Berners-street, W., designed by Mr. Howard Swan, of which we give a sketch. As will be seen from the illustration, the switch is on a very simple principle. The two double spring contacts, to which the ends of the wire are screwed, are bridged across by a brass connecting piece when the handle is turned. A quick break is obtained by the action of a steel spring bearing upon the end of the connecting piece in the manner of the blade of a pocket knife. The wires come in through two holes at the upper edge, making it easy to wire and fix, and the screw cover allows of easy after inspection. The covers are of boxwood, rosewood, or ebonised wood of neat and ornamental pattern suitable for house lighting.

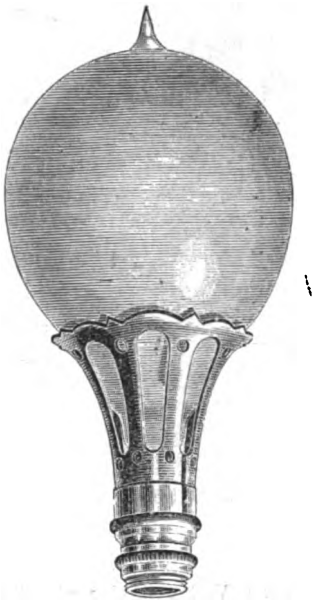
The main point in this switch seems to be that the contact is a pure electrical "bridge-over," *i.e.*, the circuit does not go through any joint of the moving parts where oil or dust might add to the resistance. The double-spring contacts give a good conducting surface, and the switch may be used for 1 to 6 lamps at 100 volts.



Bridging Switch.
Top View, showing connections.

Side View.

The same firm have also recently introduced a new form of lamp-holder of an ornamental pattern which they term the Sydenham holder, and which is certainly a great improvement upon the somewhat amateurish holders which have so long held the market. The graceful lines of the incandescent lamp are here carried on by the outline of the holder, which at the same time serves to cover up the actual joint of the wires.



Faraday's Sydenham Holder.

The holder is made of pierced brass—polished, bronzed, or silvered—passing over a boxwood block, on which are mounted the connecting screws, and the spring contact hooks for the lamp. The lamp can be hooked on at ease to these hooks ; the holder is then pressed up to the neck of the lamp, and the whole tightened up with the backnut, which puts a slight tension on the springs. Messrs. Faraday have just introduced a larger size of these holders, giving greater space (⅜in.) at the point of connection.

THE VORTEX TURBINE.

Messrs. Gilbert Gilkes and Co. have been engaged for many years in the manufacture of the Vortex water wheel or turbine invented by Prof. James Thompson, C.E., F.R.S., &c., and during this time it has been brought into extensive use for a great variety of purposes in all parts of this country and abroad. It has been applied on falls ranging from 3ft. to 400ft. Since the development of electric lighting these turbines have been largely used for this purpose, and are successfully driving various installations on falls of varying heights. The Vortex turbine is made with the outer case and guide blade chamber complete in one piece ;

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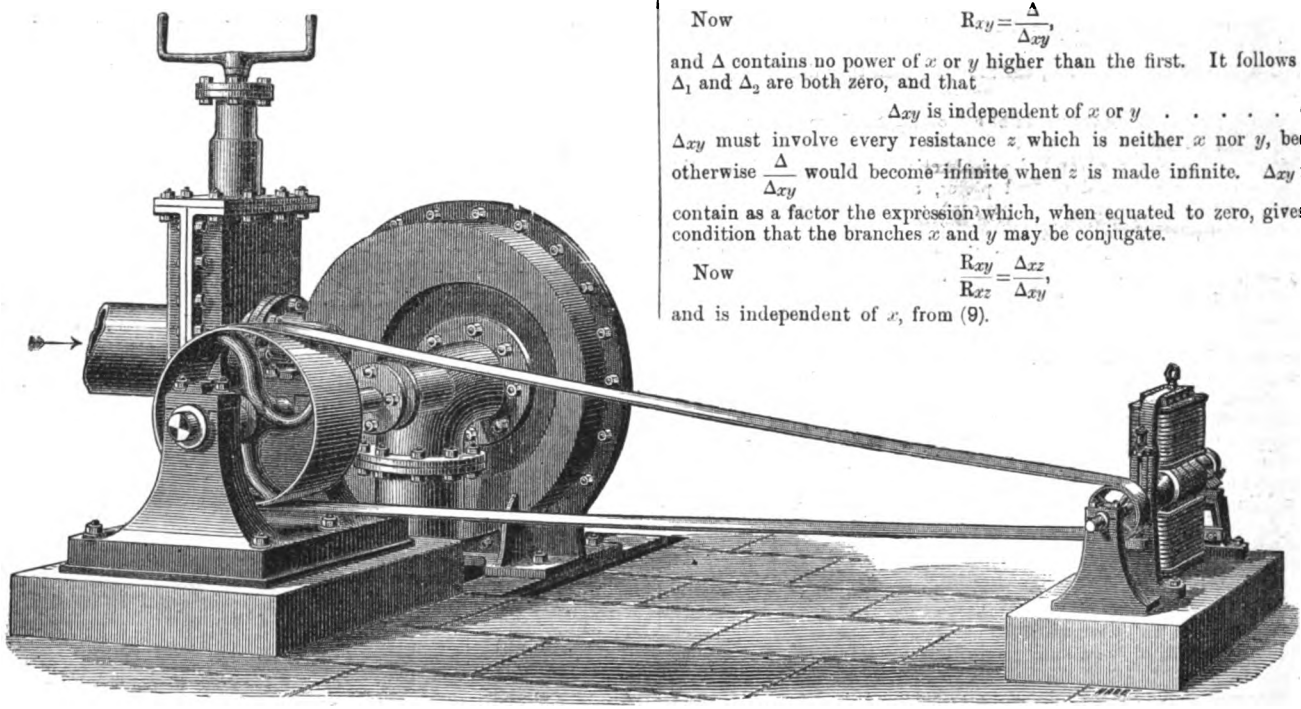
the foundation and method of fixing are consequently very simple. By means of movable guide blades the power can be adjusted with great ease to suit varying requirements. The water space being reduced equally around the periphery of the wheel, loss by shocks is avoided, insuring also a uniform speed under varying loads.

This turbine departs from the best known types, such as the Fourneyron or Jonval, in the manner in which the water passes through the guide chamber. It will be borne in mind that in turbines of the Fourneyrou type the water enters at the centre and leaves by the periphery of the wheel, and in the Jonval turbine the flow is in a direction parallel to that of the axis of revolution. In the Vortex turbine the water enters at the circumference of the wheel, and leaves on both sides of the centre by *suction pipes*. These suction pipes are another distinctive feature worthy of note, inasmuch as by their means the turbine can be erected *above* the tail race at any convenient height not exceeding about 25ft.

It is obvious that the elevation is limited to something less than the height of the water barometer. The full height of the fall is also still utilised, for the apparent loss of lead is made good by the action of the suction pipe. And this is done with the same certainty and effect as if the wheel were placed horizontally at the bottom of the fall. The turbine can thus be placed vertically, and so coupled direct to the work without intermediate gear; or, if gearing is necessary, since the power is transmitted with parallel shafts, the loss is less than when mitre gear is used. This peculiarity makes them especially adapted for high-speed machinery, such as dynamos.

Installations have been carried out in this manner at Cragside, the residence of Lord Armstrong, and at Braemore at Sir John Fowler's house.



The Vortex Turbine.

Our illustration shows a Vortex turbine placed vertically above the tail race and coupled to a small dynamo by belting. The delivery and suction pipes are sufficiently clearly indicated without further note. The demand for the utilisation of water-power is continually increasing, and we have no doubt but that Messrs. Gilkes and Co. will have plenty of work for the Vortex turbines in connection with the electrical transmission of power.

THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION, AND CAPACITY.

BY W. E. SUMPNER, B.SC.

(Continued from page 190.)

Now if the currents in the $(n+1)$ branches $a\ b\ c\ \ldots\ x$ are such that no one can be deduced from the others whatever the resistances of the remaining $(2n-1)$ branches, the $(n+1)$ branches in which they flow must be each short-circuited by making these resistances zero; otherwise three or more of the branches $a\ b\ c\ \ldots\ x$ will be brought together at a point which is only connected to the rest of the network by the branches so brought together. Under these circumstances one of the currents will be deducible from the remaining n, and this is contrary to supposition.

If, on the other hand, the currents in $(n+1)$ branches $a\ b\ c\ \ldots\ x$ are such that one is deducible from the rest whatever the resistances of the remaining $(2n-1)$ branches of the network, similar reasoning shows that these $(n+1)$ branches cannot be each short-circuited by diminishing the $(2n-1)$ resistances to zero.

The truth of (7) is now established.

Now, by definition,

$$R_{xy}=\frac{\Delta}{\Delta_{yx}},$$

and we may write $\Delta_{yx}=\Delta_{xy}$, since $R_{xy}=R_{yx}$.

Now Δ is of degree $(n+1)$ and Δ_{xy} of degree n. Δ_{xy} cannot contain the square of any resistance; for suppose $\Delta_{xy}=z^2\Delta_1+\Delta_2$, where z is any branch which is neither x nor y. The only effect of making z infinite is to diminish the degree of the network by unity, for two points and three branches are removed. We shall get

$$R'_{xy}=\frac{\Delta'}{\Delta'_{xy}},$$

where, since the degree of the network is now $(n-1)$, Δ' will be of degree n and Δ'_{xy} of degree $(n-1)$. If $\Delta_{xy}=z^2\Delta_1+\Delta_2$, and we make z infinite, the new value of R_{xy} will be zero unless Δ contains a term $z^2\Delta''$. It is physically impossible for R_{xy} to be zero, for finite electromotive forces will then produce infinite currents, and if Δ does contain a term $z^2\Delta''$ the new value of Δ will be of degree $(n-1)$, whereas it must be of degree n. Since x, y, z are any three branches of the network, it follows that

Neither Δ_{xy} nor Δ can contain the square of any resistance in any of its product terms . . . . . (8)

Now, since Δ_{xy} is symmetrical in x and y, it may be written

$$\Delta_{xy}=(x+y)\Delta_1+xy\Delta_2+\Delta_3.$$

But, from physical considerations, R_{xy} must become infinite whenever x or y becomes so.

Now $$R_{xy}=\frac{\Delta}{\Delta_{xy}},$$

and Δ contains no power of x or y higher than the first. It follows that Δ_1 and Δ_2 are both zero, and that

Δ_{xy} is independent of x or y . . . . . (9)

Δ_{xy} must involve every resistance z which is neither x nor y, because otherwise $\frac{\Delta}{\Delta_{xy}}$ would become infinite when z is made infinite. Δ_{xy} must contain as a factor the expression which, when equated to zero, gives the condition that the branches x and y may be conjugate.

Now $$\frac{R_{xy}}{R_{xz}}=\frac{\Delta_{xz}}{\Delta_{xy}},$$

and is independent of x, from (9).

It also follows that $$\frac{R_{xx}}{R_{xy}}=\frac{\Delta_{xy}}{\Delta_{xx}},$$

and is independent of x, since Δ_{xx} does not contain x.

Hence $\frac{R_{xy}}{R_{xz}}$ and $\frac{R_{xy}}{R_{xx}}$ are independent of x . . . . (10)

These properties but express the physical fact that if in a network of conductors there be a source and sink of electricity, and the current entering the one and leaving the other be known, the amount of the current in any branch is perfectly determined, supposing no intrinsic electromotive forces in the network.

Now $$R_{xx}=x+R_{ox}=\frac{\Delta}{\Delta_{xx}};$$

whence $$R_{ox}=\frac{\Delta-x\Delta_{xx}}{\Delta_{xx}} \quad \ldots\ldots\ldots (11)$$

Now $\Delta - x\Delta_{xx}$ is the value of Δ when x is put equal to zero, and Δ_{xx} is the coefficient of x in Δ, and R_{ox} is the resistance of the network between the extremities of x, supposing x removed.

This is an expression for the resistance between any two points of any network whatsoever.

It follows from (5), (6), and (7) that R_{xy} is perfectly determined when the branches x and y meet at a network junction.

We have therefore fully determined

$3n$ network functions of the form R_{xx},
$6n$, , , R_{xy}.

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The condition of conjugacy can be readily deduced from Maxwell (Vol I., sec. 282A).

Let A and C be the extremities of the branch x of the network.

„ B and D „ „ „ y „

„ $R_{(AD)}$ be the resistance of the network between the points A and D.

„ $R_{(DC)}$ „ „ „ „ D and C.

„ $R_{(CB)}$ „ „ „ „ C and B.

„ $R_{(BA)}$ „ „ „ „ B and A.

Let A B C D denote the potentials of the corresponding points on the network. By supposition the branches x and y are not directly connected. Join the points A D by a wire of resistance z and containing an electromotive force E, and let E be the only electromotive force in the network;

then
$$\frac{A-D}{E}=\frac{R_{(AD)}}{z+R_{(AD)}}.$$

But by Maxwell—Vol. I., sec. 281, equation (10)—we have in this case

$$\frac{A-D}{E}=\frac{2\Delta'_{ad}}{z\Delta'},$$

where Δ' is a determinant of the conductivities of the branches, and Δ'_{ad} one of its minors. It follows

$$\frac{2\Delta'_{ad}}{\Delta'}=\frac{z}{z+R_{(AD)}}R_{(AD)}.$$

z in our case is infinite, so that

$$\frac{2\Delta'_{aa}}{\Delta'}=R_{(AD)};$$

and Maxwell's equation of conjugacy (sec. 282A) becomes

$$R_{(AD)}+R_{(BC}=R_{(AB)}+R_{(CD)}.$$

Now, whenever this is satisfied, Δ_{xy} must vanish. Δ_{xy} must therefore contain as a factor

$$R_{(AD)}+R_{(BC)}-R_{(AB)}-R_{(CD)} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Maxwell's investigation shows

$$R_{xy}=\frac{2xy}{R_{(AB)}+R_{(DC)}\cdots R_{(AD)}-R_{(BC)}} \quad . \quad . \quad . \quad . \quad (13)$$

$$=\frac{\Delta}{\Delta_{xy}}=\frac{2xy}{R_{(AC,\,BD)}}, \text{ suppose.}$$

Now, if x and y be any two branches, we may write

$$\Delta=x\Delta_1+y\Delta_2+xy\Delta_3+\Delta_4 \quad . \quad . \quad . \quad . \quad (14)$$

where Δ_1, Δ_2, Δ_3, and Δ_4 are independent of x and y; whence

$$R_{(AC,\,BD)}=\frac{2xy\Delta_{xy}}{\Delta}, \text{ and } R'_{(AC,\,BD)}=\frac{2\Delta_{xy}}{\Delta_3},$$

where $R'_{(AC,\,BD)}$ is the value of $R_{(AC,\,BD)}$ when x and y are each infinite; or

$$R_{xy}=\frac{\Delta}{\Delta_{xy}}=\frac{2\Delta}{\Delta_3 R'_{(AC,\,BD)}} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Δ_3 being the coefficient of xy in Δ.

Now
$$R_{xx}=\frac{\Delta}{\text{coefficient of } x \text{ in } \Delta}$$
$$=\frac{x\Delta_1+y\Delta_2+xy\Delta_3+\Delta_4}{\Delta_1+y\Delta_3}.$$

Change y to y' and let the new value of R_{xx} be R'_{xx}: we easily obtain

$$\frac{1}{R_{xx}}=\frac{1}{R'_{xx}}+(y'-y)\frac{\Delta_1\Delta_2-\Delta_3\Delta_4}{\Delta\Delta_1},$$

where Δ' is the value of Δ when y' is put for y.

But from (19) we obtain

$$\frac{1}{R_{xx}}=\frac{1}{R'_{xx}}+\frac{y'-y}{R_{xy}R'_{xy}},$$

and from (9) we have

$$\Delta_{xy}=\frac{\Delta}{R_{xy}}=\frac{\Delta'}{R'_{xy}};$$

whence

$$\Delta^2_{xy}=\Delta_1\Delta_2-\Delta_3\Delta_4 \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

so that Δ possesses the property that whatever branches x and y be chosen $\Delta_1\Delta_2-\Delta_3\Delta_4$ is a perfect square (see 14), and whenever two branches are conjugate Δ breaks into factors.

$$R_{xy}=\frac{\Delta}{\pm\sqrt{\Delta_1\Delta_2-\Delta_3\Delta_4}} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

This determines R_{xy} in all but the sign. If it is only necessary to determine the integral of the current through one branch of the network, the network functions may be considered positive quantities if the positive direction of any branch be determined according to the definition already given. Otherwise a direction in each branch must be chosen arbitrarily as the positive direction, and the resistance function R_{xy} must be defined according to equation (13) or equation (15), where A and B are the positive ends and C and D the negative ends of the two branches respectively. In this case Maxwell's investigation shows that a positive electromotive force E_x in the branch x will produce a current E_x/R_{xy} in the positive direction of the branch y. With this convention we can generalise equation (5); for if w be any branch of the network, and if x, y, z be any three branches meeting in a point, we have

$$\frac{1}{R_{wx}}+\frac{1}{R_{wy}}+\frac{1}{R_{wz}}=0 \quad . \quad . \quad . \quad . \quad . \quad (18)$$

where the branches are supposed to have their positive ends at the point. If one of the branches has its negative end at the point the sign of the corresponding network function must be changed. This equation but expresses the fact that the accumulation of electricity at the point is zero.

(To be continued.)

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis:—

RECHERCHES SUR LA CONDUCTIBILITE GALVANIQUE DES ELECTROLYTES.*

BY SVANTÉ ARRHENIUS.

FIRST PART.

ON THE CONDUCTIVITY OF EXTREMELY DILUTE AQUEOUS SOLUTIONS DETERMINED BY MEANS OF THE DEPOLARISER.

Critical Analysis by OLIVER LODGE.

Whatever may have been the importance of the *First Part* of this memoir at the date of its appearance (1883), the publication last October in Wiedemann's *Annalen* of a masterly memoir by Prof. F. Kohlrausch on the same subject throws it into the shade; for there can be no doubt that while the ground covered by both is similar, the Kohlrausch memoir is greatly superior, both in the experiments made and in the discussion upon them.

A brief abstract of this portion of Dr. Arrhenius's paper is all therefore that is now necessary; and if my criticisms on parts of it appear in any case caustic, I must express my regret to the author for the adverse opinion, and trust that my appreciation of a great deal in the Second Part will compensate for it to some extent. It seems to me that the author allows himself occasionally to indulge in an exploded type of reasoning, wherein, by manipulation of imaginary data, a confusion is produced, out of which emerge several laws more or less in agreement with experience, which are thenceforth labelled and referred to as theoretical deductions. I proceed to give an account of the contents.

§§ 1-8 are devoted to an account of the experimental method employed, and to a justification of it.

The method consists in the use of a differential galvanometer, one of whose branches consists of ordinary wire, while the other contains a current alternator in the shape of a wheel turned by hand, with alternate bars on its periphery rubbed by two springs (Edlund's "depolariser"). The alternating current from this instrument is led to a switch, which is able at pleasure to throw into circuit either the experimental tube of liquid or a wire resistance box.

A battery is arranged so that its current divides fairly equally between the two branches of the galvanometer; and one portion of the current, after being rendered alternating by the above arrangement, is diverted by the switch either to the electrolyte or to the adjustable resistance box. The resistances of the liquid and of the box are considered equal when the deflection of the galvanometer is independent of the position of the switch.

I must confess to surprise that this can be a satisfactory mode of measuring resistance: self-induction and electro-chemical capacity being so mixed up in it. Apparently, however, results fairly comparable with each other can be obtained.

§ 9. *Calculation from the Experimental Data.*—First, the conductivity of the original water used as solvent is subtracted from that of the solution, and the result claimed to be the conductivity of the salt alone. For this rule, as an empirical process justified *a posteriori*, there may be something (not much) to be said. But as a corollary from a "law" subsequently proved in this paper it is worthless. Possibly not much harm is done by using this rule in the special cases considered; at any rate, Kohlrausch does the same thing, but it is well to notice that the rule $k=k_1+k_2$, for conductivity of soluble salt and solvent respectively, assumes two things:

1st. That the law of divided circuit must hold when two conductors are intermingled; which is untrue.

2nd. That the conductivity of water itself remains unaffected by the presence of a foreign body; which is improbable.

Effect of Dilution.—A great part of the paper is taken up with the effect on conductivity which dilution with an equal quantity of water causes to solutions of various salts. This mode of expression is a roundabout sub-

* Mémoire présenté à l'Acad. des Sciences de Suède le 6 Juin, 1883. Published at Stockholm, Konigl. Boktryckeriet. Norstedt and Söner.

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stitute for a straightforward expression by curve or formula for the relation between conductivity and concentration such as Kohlrausch attempts to give. However, as Dr. Arrhenius evidently prefers this mode of expression, and thinks a good deal of it, I translate his introduction of it (page 25 of his memoir).

"Table A shows that when a saline solution is diluted in a certain ratio [1 : 6·08, for instance] its conductivity diminishes in a certain other ratio [not in general a very different one]. To render these numbers comparable among themselves in the different series a recalculation has been made, in which all dilutions are reduced to the ratio 1 : 2.

"This calculation is made in the following manner. If $1 : u$ is the proportion between the dilutions of two solutions of the same salt examined consecutively (*i.e.*, if one of the solutions is at times as dilute as the other), the proportion between the resistances in the two cases is, say, $1 : n$ (the value of n being taken from the table); that is to say, one of the solutions has a conductivity n times less than that of the other.

"If now $1 : x$ is the proportion between the resistances of two solutions when the dilutions are in the proportion 1 : 2, the following relation will hold good. If the dilution is $1 : 2^{\nu}$, the ratio of resistance (if the process is effected in a uniform manner) ought to be $1 : x^{\nu}$. In consequence we have $1 : 2^{\nu} = 1 : u$, and $1 : x^{\nu} = 1 : n$, which enables x to be calculated by the following formula :—

$$\log\log x = \log\log n - \log\log u + \log\log 2.$$

"The values of x calculated from this formula, which, according to what has just been said, signifies the proportion in which the conductivity of one salt solution diminishes when it is diluted with water to double its volume, are laid down in Table B. This quantity we name the *exponent of dilution.*"

B is a long table wherein, after all, x does not turn out a constant—though it is roughly so, several values of x being given for each substance according to its degree of dilution. The values of x for all the substances range from 1·7 to 2·3, and their average value would seem to be about 1·95.

The introduction to the above formula for calculating x loses all meaning unless x is intended to be constant; but in so far as x is intended to be constant, the gist of the introduction may be paraphrased thus :—

The first approximation to the relation between k and m (conductivity and concentration) is that made by Kohlrausch, viz., that the two are proportional. This is roughly true for very dilute salt (not acid) solutions, but it breaks down in a manner shown by Kohlrausch's experimental curves for more concentrated ones, so that he suggests the formula—

$$k/m = A - A\,m^{\frac{1}{3}}$$

as a still closer, though still rough, approximation.

Arrhenius, however, prefers to assume that k is nearly proportional to m^r, where r is an index to be determined by experiment. This is fair enough as an hypothesis, and should have been set forth clearly, and then negatived by the result of his experiments in so far as they are dependable; the result, namely, that r varies from ·946 to 1·046; or, as a clumsier and bulkier proceeding, the value of r might be tabulated for every substance at various strengths. Instead, however, of calculating r, Arrhenius calculates 2^r, a number of no particular convenience; this he calls x, and tabulates. This number x, his *exponent of dilution*, he calculates from the equation—

$$\frac{\log x}{\log 2} = \frac{\log k/k^1}{\log m/m^1} = \frac{\log n}{\log u} \left[= r \right].$$

The power of confusion is very great, and I must confess that it has cost me a good deal of trouble to disentangle the real meaning of this said dilution exponent, and of the ideas involved in it.

I ought here to say that in 1884 M. Bouty independently expresses his results in terms of this same number, which he calls the ratio λ, showing that it has some experimental convenience. Bouty, however, does give absolute concentrations, and he *really* doubles the dilution each time. Arrhenius gives no absolute concentration; he dilutes largely, and then calculates what would have happened if he had only doubled the dilution by means of a formula which, after all, is not really correct. It is this, and still more the setting up the number as deduced from theoretical grounds, which one feels bound to condemn. Perhaps the idea in not giving absolute concentrations is that it is impossible accurately to tell them unless absolutely pure water were available to start with. But the difficulty of impure water tells just at much at every dilution, for it is a medley of things you are really adding. A great part of the merit of Kohlrausch's recent memoir is that he takes such immense pains over the quality of his water.

§ 10. List of bodies examined.

§ 11. Table A, giving resistance and temperature of different strengths of solution of the various substances, but no absolute strengths are given; *ratios* of dilution are all that are specified. The columns, in fact, show $1/n$ and $1/u$.

Table B contains the "exponents of dilution," x, calculated for the different substances; it tends to show a slow increase in x as the solution becomes weaker.

Table B′ contains similar numbers, calculated from some experimental results of Lenz for stronger solutions.

The net result of these tables is that they help to confirm the later results of Kohlrausch. For all salts other than hydrates the value of x becomes practically equal to 2 as the solutions become very weak (*i.e.*, r becomes unity), and this means simply that k/m for such solutions is approximately a constant.

For stronger solution x diminishes, and this means simply that k/m fal's off, just as Kohlrausch's curves more instructively show.

§§ 12 and 13. *Discussion of the Tables.*

§ 14. *Influence of Temperature on Conductivity.*—Dilution and heating exert a similar influence on molecular conductivity.

Chapter III.—Theory.

§ 15. *On Conductivity considered as a Function of Concentration.*—Kohlrausch and most authors suppose that k/m is constant for extreme dilution; "nevertheless he seems to make the statement with a certain reserve, for in another passage he says, 'This number [gramme-molecules per c c.] can, according to all the experiments, be put proportional to the conductivity of attenuated solutions, provided *extreme* attenuation be excepted.' Nevertheless it is not difficult to prove that such a proportionality follows from the principles postulated in his work, and that precisely for solutions of extreme attenuation."

Then follows a proof from Kohlrausch's surmises, and from Hittorf's hypotheses—

(1) *That k/m is necessarily constant;*
(2) *That when two or more salts are dissolved the conductivity of the whole is the sum of the separate conductivities;* and
(3) *That the conductivity of a solution equals the sum of conductivity of salt and solvent.*

To all this it is necessary and sufficient to remark that the surmises of a philosopher, which are, to some extent, upset by his own experimental results, and accordingly by him stated "with a certain reserve," afford a very insecure basis for an elaborate proof, and for deductions therefrom.

If it be once granted—1st, that the conductivity of the water in solution is, under all circumstances, *nil*, or extremely small; 2nd, that every atom of a salt added conducts equally, and independently of every other—the laws stated are pretty obvious without further proof. But it is of little use attempting to prove these laws by begging the question.

§ 16 contains statements numbered (4) and (5), viz., *If the three laws are not true, it must be because of chemical action between the substances.*

§ 17. Hydrates (*i.e.*, hydrogen compounds, like acids and bases) are peculiar; either because they dissolve glass or because impurities contained in distilled water act upon them chemically, and alter them.

§ 18. Statement No. 6.—*The "exponent of dilution" is less than 2 for salts, greater than 2 for hydrates.*

§ 19. *Exceptions.*

§ 20. *Nature of the Resistance of Electrolytes.*—A hypothetical discussion of the friction between atoms, the mode in which ions rub against other molecules, and of the amount of rotation they produce in them, with three conclusions, numbered respectively—

(7) *The resistance of a solution is greater as the internal friction is greater.*
(8) *The resistance is greater as the ions are more complex.*
(9) *The resistance is greater as the molecular weight of the solvent is greater.*

§ 21. *Properties of Solutions of Normal Salts.*—Discussion of some results of Hittorf, and four statements—

(10) *Salts which are able to form double salts are most liable to have complex molecules.*
(11) *Aqueous solutions contain the electrolyte dissolved, at least partially, in the form of molecular complexes.*
(12) *Dilution diminishes complexity towards an asymptotic limit.*
(13) *The limit towards which the complexity of a dissolved normal salt approaches at extreme attenuation is the same for all normal salts.*

I feel that this brief analysis is not quite fair to the contents of these last sections, which are ingenious and interesting; but I scarcely think a detailed discussion of them would repay perusal, inasmuch as the author allows himself rather too freely the use of hypothesis concerning wholly unknown molecular interactions. Perhaps it will be fairer if I give the *résumé* in full.

Résumé.

"In the first six sections of the present work we have described a new method of measuring the resistance of electrolytic conductors. In this method we made use of rapidly alternating currents, produced by a depolariser constructed for the purpose by M. Edlund. We have tried to show the use of this method, and to make clear the practical advantages which it possesses.

"In the next part we have treated the process of making the observations, and of calculating the results. Then we have displayed the figures found for very dilute solutions of forty-five different bodies. Finally, we have discussed preliminarily the figures obtained, with regard to the exponent of dilution, the molecular conductivity, and the temperature coefficient.

"In Chapter III. we have, guided by the data of MM. Kohlrausch and Hittorf, laid down the proposition of the proportionality between the conductivity and the number of electrolytic molecules of a dilute solution, as well as two other propositions, according to which the figures of the previous part were calculated (1) (2) (3). Moreover, we have shown that if these propositions are not applicable, it is necessary to suppose that, with dilution of electrolytic solutions, chemical reactions are set up (4) (5). Proceeding from these different propositions, we have shown that all salts, properly so called, in solution are composed of complex molecules, which are partly destroyed by dilution. We have also indicated the manner in which these complexes are formed.

"By aid of this conception the properties of salts at all dilutions have been explained, as well as the properties of all electrolytes at considerable concentration.

"On the other hand hydrates,* and salts which partially transform themselves into hydrates, manifest other properties when much diluted. We

* By hydrates the author always means hydrogen compounds like acids and bases; and the salts next spoken of are the so called "acid" salts.

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have shown that this singularity can be explained by the action of impurities which accompany the water used to dissolve them.

"By some considerations as to the nature of galvanic resistance we have been brought to the conclusions numbered (7), (8), and (9), of which the two latter complete the first, which indicate the long known relation between galvanic resistance and internal friction. The two propositions (8) and (9) are also in agreement with published data."

(*To be continued.*)

LEGAL INTELLIGENCE.

The United Telephone Company v. The Lancashire and Cheshire Telephone Exchange Company.

In the Queen's Bench Division, before Mr. Baron Pollock, on Wednesday, an action was brought by the United Telephone Company against the Lancashire and Cheshire Telephone Exchange Company.

Mr. Finlay, Q.C., Mr. Moulton, Q.C., and Mr. Bremner were for the plaintiffs; and Mr. Aspland, Q.C., and Mr. Lush Wilson for the defendants.

The litigation arose out of two agreements. The first was dated May 25, 1881, and it said that the defendants should in their district have the use of the plaintiffs' receivers and transmitters, paying for each instrument annually a rent or royalty of £1. The date of payment was to be January 1 in each year, and it was to be for the whole preceding twelve months, and a proportionate amount for any part of that period. It was found that this hard and fast system of payment was too inelastic, some telephones being very much more valuable to the defendants than others were, and therefore a new agreement was come to. This was dated June 23, 1885, and it substituted for the previous mode of payment that the plaintiffs were to receive from the defendants 12½ or 10 per cent. upon the gross receipts of the defendants for exchange work, and this agreement was to be in operation from January 1, 1885. It was said that the defendants were in the habit of receiving from their customers annual payments in advance. These arrangements were, of course, entered into at all periods of the year, so that some of those which were made in 1884 would have the best part of their term to run in 1885. The principal questions in dispute were under which agreement and how the payments were to be made to the plaintiffs in respect of those arrangements made by the defendants the payments for which were made in one year, but which were to continue into the following year. The plaintiffs claimed that there was due to them £7,786 and interest.

Considerable correspondence was laid before the Court, and a long argument was addressed to his lordship.

Baron POLLOCK, in the end, said that the case was not entirely free from difficulty, but he thought that all the accounts up to the end of 1884 should be settled on the basis of the old agreement; and any money earned subsequently should be paid for under the agreement of June, 1885. According to an arrangement made it would be referred to an accountant to settle what, upon this basis, was due to the plaintiffs, and there would be judgment for the plaintiffs for that amount, with interest at 5 per cent.

Judgment was accordingly given for the plaintiff.

COMPANIES' MEETINGS.

Eastern Telegraph Company (Limited).

The thirtieth half-yearly general meeting of this Company was held on the 14th inst., at Winchester House, Old Broad-street, under the presidency of John Pender, Esq.

The SECRETARY (Mr. George Draper) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN stated that the revenue for the last six months ended March 31st last had been £331,862, being a decrease of £9,543 compared with that of the corresponding period of 1886. The balance brought forward from the last half year's accounts was £19,458 less than in 1886. They now had to deal with the sum of £28,902 less than at that time last year. The total working expenses for the half year had been £33,035, or a decrease of £9,209. That arose in a measure from the absence of extraordinary expenses, which were unavoidable in time of war. The general expenses in London had been £8,169, being a decrease of £604. The working expenses at stations had been £60,674, against £64,439. The expenses attending repairs and renewals of cables had been £43,903, being an increase of £2,266. One of the items in that account was for the completion of the repairs to the Direct Lisbon cable, which had now been almost entirely renewed. One of the company's ships, the screw steamer "John Pender," had been fitted up with new boilers and improved electric light, and thoroughly overhauled and re-classed at Lloyd's. The expenses of carrying out that work, together with the extensive alterations and improvements which were made to the hull, and picking up the gear, &c., of the screw steamer "Volta," had been charged to maintenance ships' fund. They had laid in about 135 miles of new cable during the six months. Notwithstanding the reduction in revenue to which he had referred, it was satisfactory to find that after charging all expenses, including income-tax, providing for interest on debentures, debenture stock and preference shares, they were still able to pay a dividend and bonus on the ordinary shares at the rate of 5½ per cent. for the year, and to carry forward £48,000 to the general reserve fund. When he had the pleasure of addressing them last January he told them that they had been paying a bonus for some two or three years, but he then stated that the reductions which were forced upon them at Berlin took away something like £40,000, and that that practically did away with their bonus. He thought that on the same occasion he shadowed forth the probability—believing as he did in the recuperative power of the telegraphic system—that a year would not pass away without at any rate their being able to pay some portion of, if not all, the bonus. Strange to say, during the first few months of the reduction in the rates there had been a decrease rather than an increase in their traffic. That, however, was temporary, and he was glad to say that in the last two or three months there had been an increase, and they were now enabled to pay for the six months a bonus of ½ per cent. He hoped that would be satisfactory to the body of the shareholders. Since he last addressed them they had connected Tangiers with their cable system in Gibraltar. They found that there was a great want of telegraphic communication, and they were requested to do this work, which he was glad to say, had met a great public want. The cable was working satisfactorily, and the return had been much in advance of what had been anticipated. That would be another feeder to their system. The Italian Government had also, under the Company's more immediate eye, laid a telegraph connecting Massowah and Assab with the Company's station at Perim. That would be an additional feeder to their system. The Company undertook to protect that cable for three months, for which they received £5,000; and that was very satisfactory, seeing that no work had been required from them for it. There was another important question which he shadowed forth at the last meeting. He then said that to make themselves thoroughly independent it might be necessary to lay another cable from the Land's End to Gibraltar and Malta, to make them entirely independent of their cable system through France. Looking at the state of affairs on the Continent, probably they had not undertaken to do that work one day too soon. Anyone reading *The Times* of that day must be struck with the critical position in which Europe was at the present moment. It had always been the policy of the Directors to be ahead of requirements in their work. They believed they had the support of the shareholders in thus acting, as long as they saw their way to maintain their dividend. In carrying out this work they would saddle the Company with a very small amount of capital, and it would give them independence in maintaining their dividend. They had had a line through France for some years, which they had occupied very considerably, but they had felt that it was not a safe line to rely upon, and difficulties were being thrown in their way by the French Government to their renewing the concession. They had before anticipated the wants of the Government, and they believed that they were now anticipating the requirements of the Government and of the nation, and that in doing so they were adding to the stability and position of the Company. That cable could be laid and working within the next two months, and it could be laid sooner if desired. They had intimated to the Government the amount they would have to pay if at any time they required a preferential working of that cable. He believed that what they had done would commend itself to the Government, as he was pleased to find it had commended itself to the shareholders. During the last six months they had lost another steamer, the "Volta," but they could not understand how it had occurred except on the plea that the captain and officers of the ship had become so accustomed to sailing among the islands of the Greek Archipelago that they had got to believe that the ship could take care of itself. The Board of Trade had made a very careful inquiry, and had relieved the Company from all blame, reporting that the vessel had been kept in a most efficient condition. The misfortune had been attended with no pecuniary loss to the Company. The insurance money would pay for the ship they were now building to replace the "Volta." Their 5 per cent. debentures were terminable on the 1st of August, and they had decided to issue 4 per cent. mortgage debenture stock to replace them. The stock was being taken up pretty freely by those who had the 5 per cent. debentures. The change would effect a certain saving to the Company, and he thought it showed the solid position in which the Company was viewed by the investing public. In the earlier stages of the Company he had said that the property was a property the importance and value of which they had yet to learn. Every year had taught them that they controlled and commanded it. If a fault occurred to-day, they could say within a few days, almost to a certainty, that the fault would be repaired. Therefore, they had established what might be called a permanent property, and in that light it was being viewed by those who were taking up the 4 per cent. debenture stock. It was during the last twenty years that submarine telegraphy had been established and brought to its present position, and probably nothing had been done during the 50 years' reign of Her Majesty that had left a greater mark upon human progress than the submarine system of telegraphy. The subject of federation had been much talked about. He maintained that the submarine telegraph system had been the means of bringing about a great moral confederation. It had brought our colonies and the mother country into daily, almost hourly, communication. He thought they might congratulate themselves as a company on the great work they had done. He trusted that that work would continue, that the telegraph would play an important part in preventing war, and that if war did occur it would play a still more important work in bringing it to a close. He concluded by moving the adoption of the report, and the declaration of the dividend and bonus recommended.

Mr. G. G. NICOL seconded the motion.

In answer to questions,

The CHAIRMAN said that the existing 5 per cent. debentures were a terminable security, while the 4 per cent. mortgage debenture stock would be a permanent security, and have a first charge on the Company's undertaking. When they established the bonus principle it was pointed out that the amount would be of a fluctuating character, and they agreed to consider 5 per cent. as the dividend. He hoped next half year that

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they might again pay the ½ per cent bonus. In keeping ahead of the wants of the Government and of the country they had received very great and important consideration from the Government For instance, they had the exclusive right for a great many years of landing cables in Egypt. If they were to stand still they would go back, and, in fact, they must meet the demand on them as far as possible and be ahead of it. In answer to Mr. Husband, he stated how they proposed to pay for the new cable, pointing out that the capital would be saddled with only £75,000. By the arrangements contemplated in connection with the new cable they hoped to save £21,000 a year, which they would practically get towards the payment of the interest on the new capital. He looked forward to a very large increase in their traffic. In reply to Mr. Fowler's question they were going to raise the money for the new cable in such a way as to add but little to the capital. The present arrangement with France would continue till next year; but that country might be in a blaze to-morrow. Their ship was at Porthcurrow, with a large amount of the cable on board for the new line. Some day they would have an alternative line from Bilbao to Barcelona connecting with their system, and from Barcelona they would connect with their own system at Gibraltar at a very small expense. That would give them another line.

The motion was then unanimously adopted.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

[We shall publish a full report of this meeting in our next issue.]

South of England Telephone Company (Limited).

An adjourned meeting of this Company was held at Winchester House, 50, Old Broad-street, E.C., on Tuesday, the 12th inst., Mr. David Owen Bateson presiding.

The SECRETARY (Mr. F. L. Robinson) having read the notice convening the meeting,

Mr. HENRY ROBERTS proposed, "That the sum of £200 be paid to the Directors for their services during the twelve months ending 30th April, 1887."

Mr. A. MARSHALL seconded the resolution, which was carried unanimously.

Mr. A. MARSHALL proposed:—"That the election of the Chairman as Managing Director, made by the Board, 28th October, 1886, with a salary at the rate of £500 per annum, from the 18th March, 1886, be and is hereby confirmed." The speaker made flattering reference to the able manner in which Mr. Bateson had carried on the affairs of the Company.

Mr. JOHN TAYLOR, in seconding the motion, said that if the business of the Company was conducted in the future as it had been in the past, the time was not far distant when the shareholders would find themselves in a very prosperous position, a fact which he was sure they would substantially recognise as largely due to the labours of the Chairman.

Dr. ELLIS (Eastbourne) said that, as a general rule, he did not think the Managing Director and Chairman of the Company should be one and the same person, but in the present case he had no hesitation in supporting the motion.

The resolution was agreed to *nem. con*

In answer to Mr. W. P. Ponsford, the auditor (Mr. J. Weiss) promised to give a more detailed statement of accounts next year.

Dr. ELLIS proposed, and Mr. JOHN TAYLOR seconded, the re election of Mr. Bateson, the retiring Director, which was unanimously agreed to.

The CHAIRMAN having briefly expressed his thanks,

The auditor was reappointed, and a vote of thanks passed to the Chairman, which concluded the business.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 8th inst. amounted to £3,762.

CUBA SUBMARINE TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this Company, held on Wednesday, the audited accounts for the half-year to June 30 were submitted, and it was resolved, after providing for the distribution on the preference shares, and placing £4,500 to the reserve fund, to recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax. The sum to be carried forward is £840.

DIRECT UNITED STATES CABLE COMPANY.—At a meeting of the Board of the Direct United States Company, held on the 8th inst., it was resolved to recommend a final dividend of two shillings per share, free of income tax, such dividend to be payable on and after the 30th inst., making, with the interim dividends already paid, 2 per cent. for the year ending 30th June last. Recourse will be had to the interest on the reserve fund to make up the required amount for such dividend. The transfer books will be closed from the 15th to the 29th July, both days inclusive.

FAURE ELECTRIC ACCUMULATOR COMPANY. — Messrs. Francis Cooper and Herbert Canning, the liquidators of the Faure Electric Accumulator Company (Limited), notify that they are prepared to pay a dividend of 20s. in the pound to the creditors of the Company, on application at the offices of Messrs. Cooper Brothers and Co.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY.—Notice is given that a half-yearly general meeting of this company will be held at the Cannon-street Hotel, London, on Thursday, the 19th instant, at 12 o'clock noon, for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 5 per cent., or 10s. per share, free of income tax. The company's share register will be closed from the 12th to the 20th inst., both days included.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 8th inst. were £3,154, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 13.		BUSINESS DONE WEEK ENDING JULY 13. Highest.		Lowest.	
Anglo-American	37,	38	38⅜		37⅜	
Do. Preferred	59½,	60½	61		59⅞	
Do. Deferred	14½,	15½	15⅞		15⅝	
Brazilian Submarine	11,	11¼	11 3-16		11¼	xd.
Cuba	12,	12½	11¼		—	
Do. Preference	18,	19	—		—	
Direct Spanish	2¾,	3	—		—	
Do. Preference	7½,	8½	—		—	
Direct United States Cable	9,	9½	9⅜		—	
Eastern Telegraph	11,	11¼	11¼		10⅜	
Do. 6 per Cent. Preference	14½,	14⅝	14⅜		—	
Do. 5 per Cent. Debentures, 1899	107,	110	—		—	
Eastern Extension	11½,	11⅝	11⅝		11 9-16	
German Union	10½,	11	—		—	
Globe Telegraph and Trust	5½,	5⅞	5 9-16		5⅜	
Do. Preference	13,	13½	13½		13	
Great Northern	13⅞,	14	14		13 9-16	xd.
Indo-European	34,	36	—		—	
Reuter's	7½,	7⅞	—		—	
Submarine	180,	190	—		—	
West India and Panama	⅝,	¾	—		—	
Do. 1st Preference	8½,	9	8⅞		8⅜	
Western Brazilian	8,	8½	8 3-16		8⅛	
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	104,	107	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	—		—
Oriental	½,	¾	—		—
United Telephone	12½,	13	12⅝		12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2,	2½	2¼		—
Do. (fully paid)	3¾,	4¼	—		—
Swan	1¼,	1½	—		—
Maxim Weston	3-16,	5-16	—		—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	36⅞		36½
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23⅝		23 5-16

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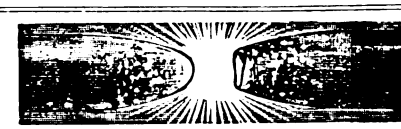
GLOBE  BRAND.

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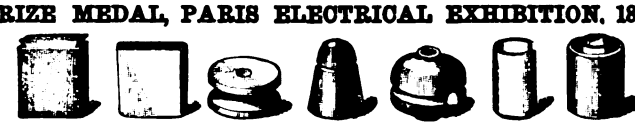

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NOTES.

HAMBURG.—The telephone line between this city and Berlin has now been opened for the public service; the distance is 150 miles. We hope shortly to give further details as to this line.

KIMBERLEY.—During the Jubilee celebrations at Kimberley, South Africa, Mr. Cousens, the manager of the local electric lighting company, carried out a number of very successful illuminations with incandescent lamps of varied colours.

BARNSLEY.—The premises of the "British Co-operative Society" have been fitted with electric lighting plant by the firm of Wilson Hartnell, of Leeds. The installation consists of a 450-light Crompton compound self-regulating machine, and, at present, about 220 sixteen candle-power Edison-Swan lamps. The dynamo is driven from the main engine, which is employed in the building.

THE TELEGRAPH IN 1857.—*The Times*, referring to the gigantic task undertaken by Mr. Samuel Palmer in compiling an abstract of the history recorded in its columns, mentions that in the description which appeared in its columns of the Great Exhibition of 1851, in the section devoted to railways the telegraph is referred to eight times only, while the word "telegram" had not as yet been coined.

EXETER.—The Western Counties and South Wales Telephone Company opened an exchange at Exeter on the 27th ult. with about a dozen subscribers. The rates charged within a one mile radius are for one year's subscription £12 per annum, for four years' agreement £11 per annum, for seven years agreement £10 per annum. It is hoped shortly to extend trunk wires to some of the neighbouring towns.

ELECTRIC TRAMWAYS.—The electric tramcars have not been running at Brussels for some days, owing to an accident to the machinery at the charging station. It is a great pity that this plant has not been duplicated.—Rumour has it that a similar consequence on a line nearer home is due to a similar cause, but on this matter we shall probably before long have more to say.—A tram line to be worked by electricity is being laid out between Bilbao and Sauturce.

PROPOSED ELECTRIC LIGHTING AT GOVANHILL.—Last Tuesday, at a meeting of the Police Commissioners of Govanhill, one of the Glasgow suburbs, a minute of the Lighting and Cleansing Committee was submitted in regard to a proposal to adopt electric lighting for the street lamps. A contractor had offered to fit up each lamp complete at a cost of 16s.; and the cost of a light of 8 candle-power in each lamp would be 12s., and one of 16 candle-power 24s. per annum. The decision was adjourned for further consideration.

"THE WESTERN ELECTRICIAN."—When such tremendously rapid progress is being made in the American States in the practical application of electricity it is not surprising to find that the roll of technical journals has been lengthened by the advent of the *Western Electrician*. Our new contemporary hails from Chicago, and is to be published weekly on Saturdays. The first number is calculated to give a very favourable impression, the articles throughout being of a description which should appeal forcibly to the class for whom the journal is intended.

TEMPORARY LIGHTING.—The United Electrical Engineering Company recently carried out a temporary installation of 15 arc lamps and 30 incandescents at Walham Green in connection with the Butchers' *fête*. In previous years this particular event has unfortunately been associated (in other hands) with rather unfortunate exhibitions of electric lighting freaks. On the present occasion special care was taken to avoid any possibility of mishap, and a spare dynamo was placed in position, although it was not needed. The committee expressed themselves highly satisfied with the result.

OVERHEAD WIRES IN MEXICO.—According to advices of June 25th, from the City of Mexico, steps are being taken to remedy the cause of so many complaints respecting the dangers and inconvenience of overhead wires in that city. The representatives of the electric light, telephone, and telegraph companies of the city have had a conference with a committee of the Municipal Council at which a proposition was agreed to in favour of the erection of posts sufficiently large to carry all the wires of all the companies, on the system carried out in New Orleans by Colonel Flad. If the proposal is confirmed, the city council will proceed to the construction and erection of the posts, and will charge a moderate rental to the companies.

THE REPORTED INJURY TO VEGETATION BY ARC LIGHTS AT ST. PETERSBURG.—At a meeting of the Electro-Technical Society of Berlin, Herr Arnold Siemens took occasion to contradict the report that the tropical plants in the Winter Palace at St. Petersburg had received any injury from the electric light. The damage was entirely due in his opinion to the way in which the plants had been removed from the hot-houses upon a night of great cold, and without sufficient protection. He had also learnt that these particular plants remained without attention for three weeks subsequently, and the blame was then thrown on the electric light. We are very pleased to have this contradiction of a report to which it was difficult at any time to give full credence.

JEHL AND RUPP'S FARADAY DISC DYNAMO.—In another column will be found a further description of the mode of constructing the armature of the interesting disc machine by Jehl and Rupp, which was described and illustrated in a recent issue. The Faraday disc experiment has already been taken as the basis of designs for dynamos by several inventors; amongst others may be named Edison, Sir Wm. Thomson, Bollman, and one form of the Elphinston-Vincent, but none of these machines, so far as we are aware, have hitherto achieved practical success. The merit of the present design consists in the very ingenious way in which the particular shape of the coils and polar faces which will give the maximum E.M.F. per revolution with least waste of space has been determined.

OPENING OF TELEPHONIC COMMUNICATION BETWEEN GLOUCESTER AND BRISTOL.—The Western Counties and South Wales Telephone Company have opened telephonic communication between Bristol and Gloucester. The trunk line from Gloucester extends to Sharpness Docks, where it joins the lines connecting Bristol with Cardiff. At the formal opening the Mayor of Gloucester delivered a speech through the telephone to Bristol, and Mr. Lewis (the general manager and secretary of the company) gave some interesting information as to the present extent of the company's business and their hopes for the future with regard to the extension of trunk lines. The company will very shortly have at work 282 miles of poles and 865 miles of wire in their trunk lines alone.

ST. BRIDE'S CHURCH, FLEET STREET, STRUCK BY LIGHTNING.—During the brief thunderstorm which burst over the metropolis on Friday last, the Church of St. Bride's, in Fleet-street, was struck by lightning. An eye-witness describes the appearance of an immense ball of a dark silver colour which descended the conductor. Fortunately the damage done to

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the steeple was very slight, a few loose stones were displaced from the belfry, and at the point where the conductor enters the ground the earth was slightly disturbed. Considering the long spell of dry weather, this speaks fairly well for the earth connection of the conductor. Some injury was done to the telephone and telegraph instruments in the immediate neighbourhood; amongst others the magneto-bell coils of our own telephone were fused.

THE "WATER BATTERY."—M. D'Humy has at length placed in the market his "water battery," about which various mysterious rumours have from time to time been circulated. The cell is made up of iron and carbon, but the carbon is constructed in the form of a narrow rectangular box, and this is filled with nitric acid. Pure water is poured into the outer cell, in which the iron plate and carbon box are placed. The percolation, or endosmose of the acid through the carbon, is, we believe, supposed to add considerably to the E.M.F. of the cell. The *Investors' Guardian* is of opinion that "this is a very important matter for the consideration of shareholders, and, in fact, of everybody having anything to do with gas companies," even, we suppose, down to the lamplighters. We observe that our worthy contemporary describes M. D'Humy as the "inventor of the Water Primary Battery Company (Limited)."

ELECTRICITY APPLIED TO LINE FISHING.—The true sportsman will certainly scout the idea that electricity can possibly lay claim to any legitimate share in the placid delights of the disciples of rod and line. It may possibly, however, be necessary to remind him that fly-fishing is not the only method of pursuing the business. Float fishing, although undeniably the very laziest kind of "sport" under the sun, is still followed, and such being the case there can be little doubt that its devotees will welcome any development which still further diminishes the necessity for any exertion in the pursuit of their ignoble art. The only room for improvement in this direction appears to lie in the possibility of rendering it unnecessary for the fisherman to keep his eye upon the float. For this end an arrangement has been devised whereby a pull upon the line closes the circuit of a tiny battery carried in the base of the rod, and this is made either to sound an alarm or to gently tickle the hand of the fisherman as he grasps the butt. The sport has thus been brought to a state of the highest perfection, for nothing now hinders him from going comfortably to sleep.

SHERLOCK'S TELL-TALE TELEGRAPH FOR STEAMSHIPS.—This is an automatic tell-tale, placed in the engine room of ships, and arranged so that should the engineer in charge misread the indication given on the ordinary telegraph dial, or should he move over the reversing link contrary to orders, an electric alarm would be set ringing, and would continue to ring until the mistake was rectified. This is done by means of a contact plate capable of moving in a vertical direction and controlled by the movement of the reversing lever. This plate has a hole in its centre, into which projects an insulated point fixed on a plate whose circular movement is worked from the finger on the dial in the engine room. When an order is signalled by the officer in charge, and is recorded on the dial in the engine room, the contact point is moved round, and if the order is fulfilled the contact plate is necessarily moved in the same direction as the point; but should the reversing lever be moved in the opposite direction, then the plate also moves in the opposite direction, thus closing an electrical circuit through the point and ringing a bell. The apparatus is made by Messrs. Johnson and Phillips, of London.

POSTAL AND TELEGRAPH REFORM.—A meeting of members of Parliament was held yesterday week for the purpose of forming an association for cheapening and extending the postal and telegraphic facilities of the Empire. Mr. Henniker Heaton was elected chairman. After a discussion, the following resolutions were carried:—1. That the postal and telegraphic communication between England and all other parts of the Empire is unsatisfactory, and therefore detrimental to British interests. 2. That a Parliamentary Committee be formed for the purpose of cheapening and extending the postal and telegraphic facilities of the British Empire. 3. That meetings of the committee be held from time to time to decide on the action to be taken for advancing the object in view. 4. That Mr. Henniker Heaton and Mr. H. L. W. Lawson be appointed joint hon. secretaries of the committee. Ninety-six members of Parliament had their names enrolled on the committee. The first steps to be taken were discussed at some length. A large public meeting will probably be held soon, and the Government will be invited to appoint a Select Committee of the House of Commons to examine into the question.

THE JUBILEE OF THE TELEGRAPH.—The arrangements for the dinner in the Holborn Restaurant on the 27th inst., in connection with the Jubilee of the Telegraph are now practically complete. The general committee met again on Tuesday at the offices of the Society of Telegraph-Engineers, when the programme was finally discussed and agreed upon. Covers will be laid for about 240 gentlemen, and amongst the speakers will be the Right Hon. Cecil Raikes, M.P. (chairman); Mr. Edwin Clark, Mr. John Pender, Sir Wm. Thomson, Sir Lyon Playfair, M.P.; Prof. Stokes, Sir Frederick Bramwell, Mr. Shaw Lefevre, M.P.; Mr. Bruce (President of the Society of Civil Engineers), Sir Charles Bright, Sir Algernon Borthwick, M.P., &c. The sub-committee who were entrusted to make the arrangements have been most indefatigable in their labours, and have left no stone unturned to provide an entertainment worthy of so important an event. It need be no secret that, in their anxiety to do so, the gentlemen composing it, with a few of their friends, very pleasantly rehearsed some of the effects that may be expected on the 27th by dining together in the Holborn Restaurant according to the *menu* which has been fixed upon for the occasion.

SERIOUS FIRE IN THE FACTORY OF THE UNITED STATES ELECTRIC LIGHTING COMPANY.—A fire broke out in the incandescent department of the great factory of the United States Electric Lighting Company, at Newark, N. J., Friday afternoon, June 17th, and destroyed the property of the company to the amount of probably $250,000, which is, however, covered by insurance. Fortunately, all the general machine shops, laboratory, dynamo and arc lamp departments, engines, boilers, etc., were saved, the fire being confined to the south side of the immense works. The incandescent department was entirely consumed, also the office, the stock department, and glass blowing and lamp exhausting departments. The cause of the fire is supposed to have been from a gas leak or from spontaneous combustion resulting from waste. There was no electric current in the room where the fire originated. The fire burnt very rapidly, the walls falling in fifteen minutes after it was noticed. Over 300 employés are thrown out of work. A temporary factory for the manufacture of lamps has been arranged for. The company recently purchased a tract of land adjoining for the purpose of increasing factory facilities, and will now build on a very much larger scale.

THE LIGHTING OF THE BRIGHTON PAVILION.—The latest chapter in the chequered history of the Brighton Pavilion

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installation may perhaps appear to cast some doubt upon the precise utility of calling into play the services of a consulting electrician, seeing that, as the result of the specification recently issued, the highest tender exceeds the lowest in the ratio of nearly three to one. As a matter of fact, however, it is within our knowledge that there exist certain peculiarities in this case which go far towards explaining the discrepancies. We have had a mass of information placed at our disposal in this matter, but we fail at present to see that any good end would be served by its publication. To avoid misapprehension, let us add that the circumstances referred to are solely of the nature of misunderstanding, and nothing beyond this is at all hinted at in any quarter. The results of the tenders were as follows:—Anglo-American Brush Company, Lambeth, £1,510; Marshall and Co., Liverpool, £1,325; Rashleigh Phipps and Merry, 187, Gray's Inn-road, London, £990; Nicholson and Jennings, Old Kent-road, London, £904. 10s.; Brighton Electric Light Company, £720; F. Geere Howard, Oxford-street, London, £700; Gülcher Electric Light Company, £650; Bailey and Grundy, Paddington, London, £578; and Maxim-Weston Electric Company, Queen Victoria-street, London, £525.

THE LIGHTING OF THEATRES: REPORT PRESENTED TO THE PARIS MUNICIPAL COUNCIL.—The Committee of the Paris Municipal Council which, after the disaster at the Opera Comique, was instructed to investigate the whole question of the electric lighting of theatres has presented its report, of which the following are the most important passages. We may, however, premise that the Municipal Council possesses no jurisdiction over the theatres which are subsidised by the State, the control of which is wholly in the hands of the police. The report is expressed in the most emphatic terms:—"To avoid fires we must suppress their cause, namely gas. Gas should be entirely prohibited under any form whatever. Install electricity. It is not for us to appear as the patrons of any one particular industry, but the results which have attended the introduction of the electric light are absolutely conclusive in this matter. We recommend, therefore, that the Council should pronounce in favour of electricity for the lighting of theatres, but without specifying any particular system; and we would add that the motive power should be placed outside the theatre, if only for the excellent reason that in the majority of theatres it is impossible to make proper provision for the plant inside the walls." The committee recommend the appointment of a special commission to consider in detail the measures of precaution to be taken for each of the municipal theatres and for the unsubsidised places of amusement. In the discussion which followed the recent action of the Prefect of Police was strongly condemned.

JUBILEE HONOURS.—The *Saturday Review*, commenting on the distribution of honours on the occasion of Her Majesty's Jubilee, considers that "it is matter for regret that the opportunity was not taken, or did not present itself, of singling out for honour the names of men who in art, in letters, and in science have given to the Victorian era a distinction not inferior to that which belongs to it in material and political development. The House of Lords is, of course, primarily an assembly of statesmen and an instrument of public business. It is not less efficient in the discharge of those functions from the fact that they are chiefly exercised by a dozen or a score of leading statesmen, while the bulk of peers are content to be hearers only. Something like this was the case with the House of Commons in its best days. But the House of Lords is something more than a legislative chamber. A peerage is the highest distinction the Queen can confer. The House of Lords would be strengthened in that public opinion on which all institutions now depend if the principle on which the barony of Lord Tennyson was conferred were more generally acted on, and it could be made representative through suitably selected types of all that is most illustrious in the national life, in letters, science, art, industry, and the various public services. The ornamental side of institutions, especially of institutions which are supposed to exhibit the qualities which England most honours, cannot safely be neglected. Quarter-Sessions and ex-President-of-the-Local-Government-Board peerages are all very well in their way; but they are scarcely sufficient to sustain or revive the reputation of the peerage as the supreme order of merit in England. It cannot be said to have this character now; but it might have it with advantage to itself and to the nation."

PROJECTED ELECTRIC LIGHTING AT MALTON.—The notice which recently appeared in our advertisement columns inviting tenders for lighting the town of Malton by electricity or otherwise resulted in no less than twenty-four applications from electrical firms for specifications and further particulars. The specifications have been prepared by Mr. J. L. Webster, the borough surveyor, and state that the lighting district extends over about ten square miles. In the case of electricity the contractor is to state whether the mains be underground or overhead, and to give the number of lamps which he proposes to employ—so many arcs of 2,000 and 1,000 candle-power, and so many incandescent lamps of 16 and 10 candle power. Tenders are to be sent in for both one and three years, and contractors are informed that "generating stations, with all necessary power, can easily be found in different parts of the borough." At the present time the public lamps are lit by the Gas Company at a rate varying between 2s. 6d. to 2s. 8d. per 1,000 cubic feet; the company also supplying the lamps and undertaking their maintenance. The total cost does not exceed £600 per annum. Private consumers are charged 3s. per 1,000 cubic feet. In this instance it is probable that the Local Board had originally no very serious intention of utilising electricity, but merely thought it would be interesting and instructive to hear what electrical engineers might have to say. This is, perhaps, advisable as a preliminary step, provided that the firms who send in tenders have reason to think it worth while on their part to go seriously into the calculations; but as things go the chances are that the affair will result in a mere repetition of the Southport episode, where—as we may state for the information of the Malton local authorities—a similar step taken by the Corporation resulted in tenders varying from a few hundreds to many thousand pounds according to the real or factitious ideas of the tenderers as to what should constitute a satisfactory installation. We have always insisted, and shall continue to insist, that it is impossible for corporations or private individuals to obtain any valid idea as to the cost of electric lighting on any large scale by inviting open tenders from all and sundry on the basis merely of specifications drawn by borough surveyors or other non-technical persons, and which, therefore, do not profess to contain more than a vague and general idea of what they would like to get. If the Malton Local Board thinks seriously of employing the electric light—and we need hardly say that if this be the case we shall be the first to congratulate them upon their enlightenment and progressive spirit—they must be prepared to disregard the discrepancies which will necessarily appear in the tenders which they have now invited. Before coming to a definite conclusion they should invite some thoroughly competent consulting electrician to prepare a careful and exact specification, upon the basis of which they may then

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feel confident that the work can be carried to a perfectly successful issue.

A PRIMER MOST PRIME.—An American "Primer on Electricity," which has recently made its appearance, and is described as intended "for the use of persons whose duty it is to look after electric lighting plant," is probably intended as a scientific analogue of Señor Carolino's famous work on "English as She is Spoke." It strikes us, however, that the joke has in some cases been a little too carefully elaborated, and might conceivably lead to serious results. For instance, if the book should actually get into the hands of any member of the class referred to on the title page (which is, of course, part of the joke), it is just possible that they might take seriously such a passage as the following:—"Insulation.—Any substance, non metallic, can be used for insulation from paper up. It is the fact that no metal contact exists, and the various substances must be judged according to the work to be done." The latter sentence we do not pretend to fully understand; but we presume that the author will accept as a corollary the dictum that the work *being* done must be judged by the result, and we are really afraid that the results of this kind of joke are likely to be mischievous. However, there is a great deal of fun in the book of a perfectly harmless character, as, for instance, when concerning speed indicators we are told, "Of these there are various makes; but the best are those which will denote the exact speed." The section on electrical instruments is good. "Ammeter.—Ampere meter is an instrument for measuring the current in amperes. By its use (if in circuit) it will instantly show the condition of the current. Voltmeter.—Voltmeter is about the same, but gives the measurement in volts or E.M.F. Every installation should have these two instruments. Without them the party in charge is in the dark, however brilliant the light may be. If a breakdown occurs he is often unable to detect the cause." The section on electromotive-force is also "about the same," as will be seen from the following extract:—"Electromotive force expresses in electricity what steam in a boiler does to an engine, but as no circuit or work can be obtained without resistance, then we conclude that much E.M.F. is wasted in overcoming this resistance." A little later, to find further scope for his racy humour, the author indulges in a disquisition on short circuits:—"Short circuit means that the current takes the shortest path, and having no work to do causes fire. Moisture will cause a S. C. This will generally burn up the dynamo. Moisture leads to loss of current, and to the destruction of the conductor and the injudicious use of earth." We may appropriately conclude our comments in the words of the preface:—"These few hints may be of considerable benefit to the engineer (and being a man of good common sense), to such this work will, I hope, prove most valuable"—as an electrical Joe Miller.

ELECTRIC EELS FOR LIGHTING A RESIDENCE.—The *Electrical Review* of New York is responsible for a veracious story, of which the following is an abstract:—Don Miguel Santa Mezzito, a wealthy gentleman living in Achaguas, Venezuela, now at the Girard House, Philadelphia, alleges that he has succeeded in utilising electricity generated by electric eels, and that his residence is lighted by electricity by this means. Senor Mezzito is a well-educated man, graduated from Heidelburg University, and speaks several languages, including English, quite fluently. "Yes," said he, "I have my residence lighted throughout by electricity generated by large batteries of electric eels. There is sufficient electricity wasted in the streams of the northern portion of South America to light a city as big as Philadelphia, could it be properly utilised. The town of Achaguas lies on the bank of a small river of that name, which empties into the Orinoco 100 miles to south-east; it is in the State of Apure, about 150 miles from the eastern boundary of the United States of Columbia. The city is reached by boat up the Orinoco to San Fernando, and by rail from that place. Achaguas is an old town and has been the home of my family for many generations. I give you this in detail, because I have met scientists since I came to this country who evidently disbelieve that I have electric lights running by electric eels. I got my first idea of utilising the *gymnotus electricus* while studying electricity in Germany. Living as I had for years near streams in which eels abounded, and knowing personally of men and animals that had been prostrated and were killed by eels in water, I was especially interested in Faraday's account of the torpedo and other fishes. I was particularly impressed by the great scientist's statement that a full grown electric eel contained electricity equal to 15 Leyden jars of 3,500 square inches. Upon returning to my home I at once began experimenting, and was both surprised and delighted with my success, and after two years of further experimenting I succeeded in getting a battery by which a small light was run nearly an hour. Then it was merely a question of time and study. I have had the lights running, eight of them, eight-candle each, for three months. My success has brought me to this country, and I propose to explain my invention and discovery to the members of the Franklin Institute before I return to Venezuela. I first tried the placing of a number of the eels in one large rubber tank well insulated, but I afterwards discarded it, and tried the forming of a strong battery by the connection of fifty cells with two or more eels in each. The result was more than satisfactory. Each cell is so connected as to complete a circuit through the wires running from either end of the row to the lamps, which are all in one circuit. The only secret is the manner in which the electricity is conducted from the cells. That I believe to be an entirely original discovery, and I shall not divulge it until it is protected by patents both in Europe and America. The eel, I learned, makes heavy, involuntary discharges of electricity when its circulation is increased, or when unnaturally excited. I found it necessary to keep the eels excited in order to compel them to throw off their store of electricity steadily. I tried several ways of keeping a wheel revolving in each cell, but afterward learned that the placing of strychnine in the liquid in which they are kept accelerated circulation by producing tetanic contraction of the muscles, and did all that was required. 'How about when the store of electricity is exhausted, you ask?' Well, that is easily overcome. I do not allow a battery to work more than half an hour at a time. By a very simple clock-work contrivance I have so fixed things as to instantly, and at regular intervals, throw one battery off and another on. I keep these batteries of thirty cells each all the time ready. Relieved for an hour the eels are as active as ever. During the half hour of service the strychnia has become absorbed and the fishes quickly recover their natural power. Thirty cells of two eels each are equal to 1,000 volts. Each eel is a perfect battery within itself. There are two positive and two negative eels one-thirteenth of an inch in diameter in each cell. I keep a large tank full of the eels on hand all the time, and am compelled to replenish the batteries every day or two. I have attempted to propagate the eels, but thus far have not been successful. No; I do not see that my discovery and invention will ever benefit the world very much, because these eels are not found much outside of Northern South America, but it is interesting from a scientific standpoint, and I consider my time, labour, and money well spent."

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THE FARADAY DISC MACHINE OF JEHL AND RUPP.

(FROM A CORRESPONDENT.)

In *The Electrician* of June 10th the above-named disc machine was described, and the mechanical principles of its construction were indicated, while certain theoretical considerations were reserved for the present article.

If we wish to attain the best results in a dynamo electric disc machine we must recall some of the general laws of magneto electric induction.

Firstly. The electromotive force induced in a coil passing through a magnetic field is proportional to the area of the coil, but independent of its shape. The most advantageous coil is one that embraces the greatest area with the least length of wire.

Secondly. If the magnetic field is not a uniform one, or if it changes its polarity at regular intervals, the strongest induced electromotive force is obtained by a coil which is capable of embracing simultaneously the least and most dense part of the field, or in the second case the densest + and − parts of the field.

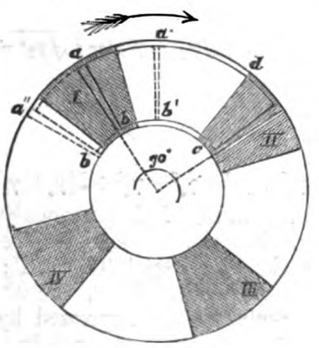
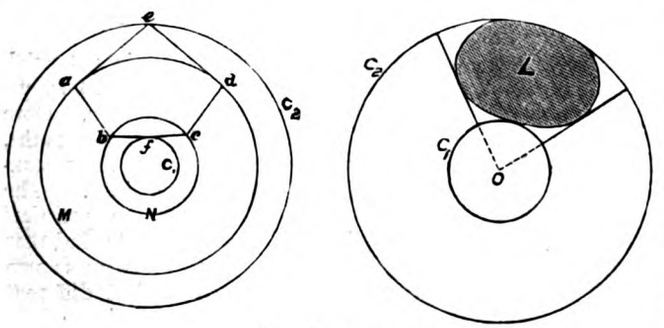


FIG. A.

Let us take into consideration a disc machine having four magnetic fields of alternating polarity. Suppose in Fig. A I., II., III., IV. to be the four pole-pieces situated on one side of the armature, I. and III. having positive, and II. and IV. negative polarity. According to the second law referred to above, the ideal form of the armature coil producing the strongest induced electromotive force would be *a*, *b*, *c*, *d*—that is—a "quadrant sector" of the armature, for it embraces simultaneously two adjacent parts of positive and negative densest polarity. The reason is obvious. We must remember that an increase of negative lines of force is equal to a decrease of positive lines, and *vice versâ*.

Therefore, if we make the coil smaller than *a*, *b*, *c*, *d*, say *a'*, *b'*, *c*, *d*, we lose the decrease of negative lines in *a*, *b*, *a'*, *b'*, and if we make the coil larger than *a*, *b*, *c*, *d*, say *a''*, *b''*, *c*, *d*, then between *a*, *b*, *a''*, *b''* an increase of negative lines takes place, and that will balance, or rather annul, an equal increase of positive lines of force at *c*, *d*; thus both are lost as far as induction is concerned.



FIGS. B AND C.

Now, the construction of such an ideal coil is very difficult, for we have to place a great number of such coils close together, the material of which will not allow us to make direct connections between *a* and *d* (Fig. B), and between *b* and *c* along the circles M and N. From the figure it is evident that *a*, *d*, *c*, F, *b* is a quadrant sector, but we are forced to surpass the two circles M and N, the circle M in the outward direction, in order to make some suitable connection *a*, *e*, *d*, and the circle N in the inward direction for a connection on *b*, F, *c*.

Then, again, it is desirable that these new parts *a*, *e*, *d*, and *b*, F, *c*, shall also participate in the induction—that is to say, the pole-pieces should be enlarged in the direction of *e*, F. Thus we obtain two new circles c_1 and c_2, between which the whole active part of the armature is enclosed.

Now, when we sum up all that has been said, we arrive at the following problem :—

(1) Given two concentric circles c_1 and c_2 (Fig. C), to fill up the space between such two circles with coils L of such a shape and size that the surface or area of L shall be as great as possible.

(2) That the tangents of L passing through the centre O shall make a sector as great as possible, but shall not surpass a quadrant.

Thirdly. That there shall be as little space as possible wasted between two adjacent coils and no false inductions. Jehl and

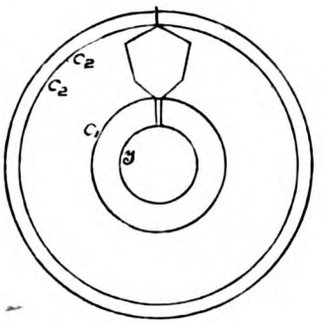


FIG 1.

Rupp have solved the problem in the following manner. As before stated, we have two circles, C' and C'' (Fig. 1), between which the active part of the armature is enclosed. The circle C_1 they call the *inner armature circle*, and C_2 the *outer armature circle*. They now take a third circle, T, smaller than C_1, described around the ends of the coils, which part serves to make connection with the commutator, and also to secure it to the shaft, as has been already explained. This circle T is very important in the construction of the coils, and it has been called the *initial armature circle*, or *the circle of reference*.

If we denote by *n* the number of coils in the armature *d*, the thickness of one coil, and δ the thickness of the insulation between two adjacent coils, the diameter of T is

$$Dy = \frac{n(d+\delta)}{\pi}.$$

That is to say, the circle T is given if the number of coils, the thickness of one coil, and the thickness of the insulation are known. Let us consider first of all such coils as consist only of straight parts (Fig. 2). Suppose *i*, *a*, *f*, *c*, *d*, *g*, and *h* to be one part or side of a coil, while *i'*, *a'*, *f'*, *c'*, *d'*, *g'*, *h'* the side of the adjacent coil as shown. To obtain good results—that is, a large area—we must attempt to make the angles between the lines *a*, *f*, and *d*, *h*, and the circles C_1 and C_2, respectively, as small as possible.

It is obvious that the angle *f'*, *a'*, C_1 cannot be made small at will, but that it is limited by the rounded part *a b* of the preceding coil. In the best case we can construct the angle *f'*, *a'*, C_1 as follows :—

Around the centre *a* we describe a circle, the radius of which is equal to the thickness of one coil plus the thickness of the insulation. The tangent of that circle passing through *a'* is then the line *a'*, *f'*.

A similar difficulty arises in the construction of the parts *d*, *h*, and *d'*, *h'*; it will be seen that there is a part, *g*, which comes very near the part, *d'*—so near that it is only separated from it by the insulation.

Therefore, in using coils constructed of straight lines we do

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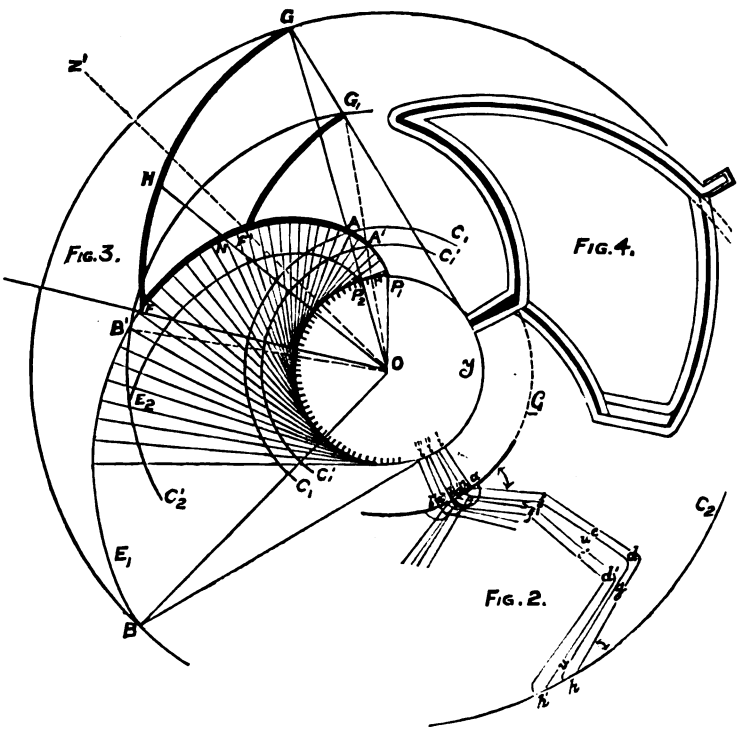
not arrive at the maximum surface, as there always remains much waste space between the coils, as *s*, *u*, *v*.

Suppose, now, that the parts *a'*, *f'*, are bent so that *f'* approaches *f*, and making also the part *d'*, *h'*, a little longer, so that *d'* may approach *d*. By this means the space *s*, *u*, *v*, is now rendered active. In like manner we can bend the preceding coil *a*, *f*, *d*, and then the coil *a'*, *f'*, *d'* can again be bent further. Hence the question arises, what kind of curve ought *a*, *f*, be? This question may be solved geometrically. Theoretically expressed, a curve was needed, which, when turned around the centre of O of C_1 would in another position remain equi-distant in all parts with its first position. Now, such curves exist, and are known as the evolute of a circle. Imagine a thread wound around the circle T (Fig. 3), and P_1 and P_2 to be two arbitrary but fixed points of that thread. If we wind off the thread, the two points P_1 and P_2 will generate two evolutes E_1 and E_2 of the circle T; that is, two curved lines, which will have at all parts the same distance, and which distance is equal to the arc $P_1 P_2$ of T. The one curve may be considered as obtained by turning the other around O. The circle T is called the circle of reference of the evolutes. As the drawing shows, such evolutes can easily be composed of a greater number of small arcs of circles, the centres of which lie on T.



Suppose C_1 and C_2 to be the inner and outer armature circle, and T provisionally a circle smaller than C_1. Construct one evolute E_1 of T, which will meet C_1 and C_2 at A and B respectively. Trace the radius O A G and O B, divide the angle A O B into two equal parts by the radius O Z. The latter will intersect the curve at a point F. Finally revert the part B F so that it shall form the curve F G, then A F G is the required form of a coil or coils. We have chosen a preliminary circle T smaller than C_1 for the construction of the evolute, but it is evident that we must take T in such a manner that the surface A F G will be maximum. That is the case if we make the angles which the curves G F and A F form with the circles C_2 and C_1 as small as possible. Now the construction shows that the line perpendicular to the curve at G or at B is a tangent of T. Therefore the angle at G becomes smaller, the smaller we make the circle T. The same is the case with the angle at A.

Now we can use the complete curve as the shape of the coils, or, in accordance with previously stated facts, taking notice that F O G is larger than 45°, we cut off the cusp F in order to obtain a coil occupying a sector a little less than 90°, like the right hand figure in Fig. 2. It will also be seen that the space enclosed by F N H is small in comparison with the length of wire, therefore we get better results by cutting the cusp off. It will also be noticed that if the coils are made and formed with the cusp, as shown in Fig. 2, every particle of space between C_1 and C_2 is utilised and is active. However, as before stated, it is better to construct the evolvents so that when the cusp is cut off the complete coil occupies a little less than 90°. In this way we gain more surface in proportion to the length. Of course it is understood that A N H G represents one half of a coil, while the other half has the same shape, only reverted. MM. Jehl and Rupp use two known formulæ, by which a chosen part of the area, such, for example, A N H G and its length, can be calculated.

Supposing A N H G to be one half of a coil, and

$$A O = \gamma_1$$
$$G O = \gamma_2$$
$$H O = \gamma_3$$
$$N o = \gamma_4$$
$$P_1 O = \gamma$$

Then the surface of the complete coil is—

$$S = \frac{1}{3\gamma}\left[{}^{2}\sqrt{(\gamma_1^2 - \gamma^2)^3} + {}^{2}\sqrt{\gamma_2^2 - \gamma^2)^3} - {}^{2}\sqrt{\gamma_3^2 - \gamma^2)^3} - \sqrt{(\gamma_4^2 - \gamma^2)^3}\right]$$

And its length—

$$L = \gamma_4^2 + \gamma_2^2 - \gamma_3^2 - \gamma_1^2 + 2(\gamma_3 - \gamma_4).$$

There is another thing of importance to be noticed. It has been shown that the surface of a coil will increase the smaller we make the initial circle T; but this also diminishes the number of coils. Now, the whole active parts or surfaces of the armature are expressed by S *n*, where *n* equals the number of coils. Now, we can imagine that if the circle T, and with it the number of coils diminishes, the *total surface* may increase considerably. This is the case, but *there is a limit.* If we surpass it, the *total surface* begins to diminish. The following rule may be laid down :—*The radius of the initial circle should be one-fourth of the radius of the outer armature circle.*

One must be careful not to confound the initial circle T with the inner armature circle C_1.

With these principles and facts the machine shown in Figs. 15 and 16 (*Electrician*, June 10) was constructed.

LITERATURE.

Elementary Lessons in Electricity and Magnetism. By SILVANUS P. THOMPSON, D.Sc., B.A., F.R.A.S. [Revised Edition.]

The fact that the publication of this useful text-book has already reached 28,000 copies is sufficient proof of its well-deserved popularity.

Having always a vigorous grasp of his subject, Prof. Thompson also possesses the valuable faculty of clear exposition, a quality which is well displayed in the revised chapter of the present edition on electro-magnetics.

This section opens with the theory of magnetic potential, which is concisely stated and explained. Article 313 is, we think, of especial value to students of the present time. Here the author, stepping aside from the formal scholastic paths, gives in exact and yet familiar language the links connecting magnetic susceptibility and permeability. The latter idea is certainly the one with which the practical student is most at home, and he will be comforted to find that unit magnetic poles, free magnetic matter, and finally his own beloved lines of force and magnetic density are but different aspects of one and the same physical condition, and are held together by no very complex bonds. The conception of magnetic shells as a means of calculating the magnetic effects of closed voltaic circuits, is next introduced, after which follow notes on magnetic and electro-magnetic units, and on the calculation of the earth's magnetic force in terms therein. A somewhat startling computation of the probable number of atoms in the

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universe, within a radius described from the earth as far as the nearest fixed star, concludes this lesson.

In turning to the succeeding lesson on electro-magnets, the most important article is No. 330, which deals with the relation between magnetic induction and magnetising force. Here we confess to a slight disappointment, for, amidst the mass of empirical formulæ which is considered as "deserving of mention," no statement is made as to that recently brought forward by Kapp, save the remark that it is analogous to Hopkinson's.

Kapp's formula for connecting the magnetic induction with the magnetising force or exciting power is perhaps the most nearly coincident with actual fact which has yet been devised, and it has, moreover, the advantage of great simplicity. As a matter of fact, Hopkinson's formula, as given, is valueless without the aid of experiment or empiricism in finding the values of μ at the various stages of excitation, and whilst it is true that the fundamental idea of "magnetomotive force" acting on magnetic resistance, underlies both formulæ, Kapp's is completed by an empirical law of saturation which gives it a practical value not, as we think, to have been so lightly passed over.

The remaining two lessons of the chapter are devoted to the treatment of electro-dynamics and diamagnetism. We are in full accord with Prof. Thompson as to the incorrectness of speaking of the attraction or repulsion of *currents* instead of the conductors conveying them, since otherwise we must necessarily conceive of a state of strain between the current and the conductor, which would presumably result in an unequal distribution of the former within the latter. The phraseology throughout is at once clear to the student and accurate in itself, and we wish the book a renewed success.

ELECTRIC RAILWAY BRAKE TESTS.

The following is the report of a sub-committee of the American Master Car Builders' Association on the application of electricity to railway brakes. The report is signed by Mr. A. H. Bowman, electrician, Lehigh Valley Railroad; Mr. E. M. Herr, acting superintendent of telegraph, Chicago, Burlington, and Quincy Railroad; and Mr. O. E. Stewart, superintendent of the East Iowa Division of the Chicago, Burlington, and Quincy Railroad:—

In pursuance with the committee's instructions in letter of May 19th we have made an investigation of the electrical appliances used by the Eames, Carpenter, Westinghouse, and Card Brake Companies in the 1887 brake test, and respectfully submit the following report:—As to the use made of electricity, we find the brakes represented naturally divide themselves into two classes, one in which electricity is entirely depended upon for the proper operation of the braking mechanism, the other in which it is used as an auxiliary or addition to braking device complete in itself. In the first class are found the Carpenter electro air-brake and the Card electric brake. In the second the Westinghouse automatic air brake and the Eames automatic vacuum brake. All the above are arranged on the open circuit system, with the exception of the Card, in which the circuit is closed, but the two batteries, one on the engine and one in the rear car, are so opposed to each other that in the normal condition no current passes through the train. In the open circuit system it is to be understood that unless the brakes are either being applied or released, no current is passing or being supplied by the batteries or other electro generating devices. This is also practically true in the closed circuit system employed by the Card Brake Company.

Taking up in order the four brakes examined, we have, first, the Carpenter electro air brake. The electrical appliances used by this brake company consists of a secondary "Julien" battery of eight cells, carried in a box upon the left hand side of the engine, securely fastened to the frame and guide yoke, and two systems of electro-magnets connected in multiple are upon the three-wire systems, one set of magnets operating the admission, the other the release valves. They also exhibited a magneto machine, by means of which the brakes could be operated by the engineer independently of the battery. This machine was not properly adjusted for the work to be done on these tests, and was therefore not used. The following diagram roughly illustrates the manner in which the electric apparatus mentioned above is connected in this brake system.

In this diagram B represents the battery, H the handle of the engineer's valve which closes the circuit A X by being moved into contact with point A, or B Z by being moved in contact with point B. In the first case the current would be caused to flow through the magnets M M1 M11, &c., returning by the common return wire, C Y, operating the admission valves and supplying the brake. In the second case the flow would be through magnets, M M_2 M_3, &c., returning over the same wire, C Y, and operating in like manner the release valves. The connections between the different cars are made automatically in coupling the brake hose by means of contact pieces in the hose coupling. These pieces are held in firm contact by a powerful spring, and are well rubbed, in coupling, making a clean, firm contact. The wires are run under the bottom of the cars and through the hose to the couplings.

The resistance of each electro-magnet was found to be 200 ohms, making for a 50-car train, when connected as shown, a total resistance of four ohms. It is worthy of note that with a battery of constant electric motive force, the resistance being increased inversely as the number of cars in the train, a constant current strength is maintained through each magnet regardless of the number of cars, making no adjustment necessary for different lengths of trains. With this arrangement of battery and resistance considerable current is used while the circuit is closed, but as this only takes place while the pressure is either being increased or decreased in the brake cylinder, it amounts to but a small consumption of battery even for a number of stops. Calculations show that with a 50 car train the breaking force could be increased or decreased continuously for about 17 hours before the strength of the battery would be destroyed, and a proportionately longer period for a shorter train. From the way in which the circuit is run it is easily seen that should an accident happen to any of the wires, causing their rupture at any point, the brakes between such point and the engine would be unaffected thereby, while those on the other section would, of course, be inoperative. This feature would enable the brakes on the forward section to be released by the engineer in case of an accidental break in two.

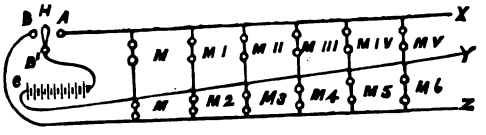

FIG. 1.—The Carpenter Brake.

We come next to the Westinghouse Electric Application Valve.

We found the conducting wires used fairly well insulated throughout their length, except at points where connection was made between wires to valves and the main conductors. No attempt at insulating of these joints is made. Perfect insulation is of great importance in this system, for should a cross occur between the two conductors, instead of the brakes being applied when an attempt was made to do so, the release, as well as the admission valves, would be open, and, should the current be maintained, the auxiliary reservoir train pipe and main reservoir would all be completely bled. Should either wire come in contact with any metallic connection either with the train pipe or any of the braking apparatus, or any part of the car forming metallic connection with the track, the result would be that either the admission valves would cease to operate by electricity, and the brakes could not be set thereby, or being set they could not be released, depending upon which wire was touched or grounded. Rain, sleet, or snow would work very much to the disadvantage of the electric appliances of this brake if the conducting wires are not well or completely insulated. It is perhaps fair to say that this brake can be applied by allowing air to escape from the engine's valve in case the current fails, but cannot be released except by electricity.

In regard to the details, we found the electric appliances admirably designed and well worked out, giving, in our opinion, under ordinary circumstances, a good and reliable arrangement. The magnet and armatures are enclosed in the cast iron cap on top of the valve, but are not within the compressed air chamber. They are separated from the rest of the valve by a heavy brass plate serving to protect the armatures from the magnetic influence of the other iron parts of the valve.

The amount of current used on a 50-car train is about 3 amperes, with an electric motive force of 16 volts, the resistance of the circuit being about 5½ or 6 ohms. Fusible safety plugs are inserted in the circuit next to the battery to prevent the possibility of the magnets being burned.

The next in order is the Card Electric Brake. This company uses two secondary batteries of a form devised by the inventor, Mr. Card, consisting of 15 cells each. One situated under the engineer's seat in the engine, the other on the rear car of the train, so connected as to oppose each other in such a way that no current passes under normal conditions. Also a system of three electric magnets for each brake connected in multiple series, together with an automatic rheostat current indicator and arrangement for cutting in and out as many cells as is desired to give the required braking force, all as shown in the following diagram:—

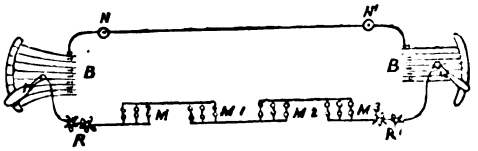

FIG. 2.—The Card Brake.

B and B' are the batteries, M M_1, &c., the systems of electro-magnet, one for each brake, connected as shown, R and R' the automatic rheostats arranged in such a way that should the train part at any point the couplings for the wires are so arranged as to close the circuit on each section, thus cutting off part of the resistance before in circuits an equal resist-

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ance would be automatically inserted at the rheostat. This maintains he current at a constant strength no matter how many or how few cars are broken off. The brake is applied while running, either by the conductor or engineer moving the handle H or H' and thus cutting in or out some of the cells, destroying the balance, and causing the current to flow through the magnets M M', &c., the amount of flow and consequent severity of application of the brakes being regulated by the number of section over which the handle H H' is moved.

he resistance of each magnet is low, being one ohm, making in resistance of the three used in each car ⅓ ohm when connected as shown. The total resistance of each car, including conducting wires, is ½ ohm, or a total of 25 ohms for a 50-car train. Although considerable current is required for the full application of the brakes, only part of it is necessary for a partial application. The current is passing in this system while the brakes are in operation, for, not only must the current pass to apply the brakes, but it must be maintained to keep them on. Calculation shows that with a battery used of the capacity of 10 ampere hours, 10 hours of the maximum application of the brake could be obtained before the battery is exhausted and of course a proportionately longer period for gentler applications. The conducting wires used by this brake company are not insulated, excepting where they are fastened to the body of the car and consist of galvanised wire cables ⅛in. thick. The couplings are arranged to complete the circuit through one wire by a sliding contact piece in the centre, the return current passing through the outside casings of the couplings. They are designed to pull apart at the couplings under all circumstances, for should the hose and connection wires be ruptured the brakes on neither section could be applied. The effect of a cross between the conducting wires here would be to apply the brakes throughout the train, and as no effort has been made to insulate the conducting wires this is an accident which, in our opinion, is extremely likely to happen either from the direct contact, or by rain, snow, sleet or other causes. The automatic rheostat is also a delicate piece of mechanism liable to get out of order, with the possible result of burning out some of the magnets, rendering the brake inoperative. The principle on which this brake is got up is admirable, but the mechanism employed somewhat complicated for train services.

In the second division we have the Westinghouse Automatic Air-brake. The electric device used by this company consists essentially of a valve inserted in the train pipe, operated by means of compressed air, which raises a piston nominally in equilibrium when its balance is destroyed by blowing off a chamber above it by means of a small valve raised from its seat by the armature of an electro-magnet. The current is passed through a copper wire insulated with rubber insulation and run through the train pipe, the return being through the metal pipe itself. The wire is connected automatically in coupling the air hose by means of contact pieces in the centre of the coupling, giving a firm contact with slight rubbing between the surfaces. The magnets used are wound to a resistance of 11 ohms each, and but three being used in these tests connected in multiple; the total resistance, about 3½ ohms for the magnets, and about two ohms for the conducting wire, is 5½ ohms. The battery used would suffice for a long time, as the wires are so connected to the engineer's valve that no electricity would be used except for emergency stops. The wires are carefully insulated, and, being enclosed in the train pipes, are well protected from the weather. Should a metallic contact occur between the wire and the pipe, however, the result would simply be to render inoperative the electric valves, which, as before stated, are entirely auxiliary to the brake mechanism. The electric features of this brake are well worked out, and, in our opinion, give a reliable and practical apparatus.

The electric appliances to the Eames Automatic Vacuum Brake are also auxiliary to the vacuum mechanism itself. It consists essentially of an electric magnet enclosed in a cast-iron cap or chamber, which can be put in communication either with the vacuum or the main valve auxiliary reservoir or with the atmosphere according as the circuit is made or broken, as explained on page 24 of the Eames catalogue. Also a metallic circuit composed of a single conducting wire and the magnets connected, as shown in red on the cut submitted herewith, the return being through the rails of the track. The current is supplied by dynamo having an armature 9in. long and 8in. in diameter; this dynamo has no governor, and is entirely beyond control and varies greatly in speed. The magnets, as is seen, are connected in series, making the total resistance equal to the sum of the resistances of the conducting wire and all the magnets, necessitating a very low resistance, in the latter 12 ohms each, and a current of considerable strength to overcome the entire resistance, which is for a 50-car train about 30 ohms. The conducting wire is fairly well insulated, and being run through the train pipe is well protected, except where it is connected to the spiral wire through the hose. The effect of any metallic contact and the conducting wire and the parts of the car in metallic connection with the track would be, as far as the electrical attachments are concerned, to cut out all the brakes between this point of such contact and the rear of the train. If the conducting wire be broken or detached in any way causing a break in the circuit, the entire electric apparatus fails. No effort was made to protect the armatures from the effect of the close proximity of iron in the other parts of the valve, and in several ways the details of the electrical attachments might be improved. The use of the track as a return is to be deprecated on account of interruption to current in case of insulated track sections put in block signal systems, drawbridges, &c.

It seems to us the whole question of the application of electricity to railroad breaking resolves itself into three important questions. First, can a valve mechanism be made operative by electricity which shall be permanent and practicable for railroad service, not having parts too sensitive or of too fine adjustment? We think it can. The valve construction as shown by Mr. Carpenter, the same which he used in these trials, is certainly not more delicate and complicated than that of the well-known Westinghouse triple valve. Secondly, can the electric conductors for working these valves be so insulated and projected as to avoid short-circuits and other injuries? We think it can by running the wires inside of the air pipes, where they are as little liable to derangement and injury, and become as permanent and certain in their functions as any other feature of the brake mechanism. In all the electric brakes shown the wires are laid inside the air hose coupling, where they are fully protected, and their connections are made from car to car easily and certainly, so that this important point is so far settled as to require no further explanation.

The remaining point is the source of the electromotive force. Of the different means employed by the companies represented, the secondary battery appears the most reliable, giving a constant current all the time until discharged, recharging being a simple process, which can be so methodically and practically arranged as not to interfere with the brake service, nor add materially to the expense. If brakes worked by electricity are to come into general use, it is probable that both battery and dynamo will give way to the magneto generator, being a small machine about 18in. square, having an easily turned crank which instantly develops the electromotive force required, so that a turn of the crank will actually apply or release the brake. One of these machines was shown us in operation upon an engine and tender brake. This apparatus may solve a most important point connected with the application of electricity to railroad brakes, inasmuch as it renders the apparatus on the locomotive independent of any special station or roundhouses, or any stated period when a battery, if used, would have to be recharged.

We believe from what we have seen at the Burlington brake tests and from a close personal examination of the several electrical arrangements for braking, that electricity properly devised and managed may be made a valuable auxiliary to actuate power brakes on long trains, and their efficiency considerably increased thereby.

CORRESPONDENCE.

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Since my letter of May 27th there have been several in your journal on the subject of electric light tenders, but very little, it seems to me, was said that is to the point. Take, for instance, the letter of Messrs. Anderson and Munro, of June 3rd. The greater part of their letter has little to do with the subject under consideration, and personally I agree with Mr. Carswell in ridiculing their estimate of £4 per carriage for fitting up the same with from eight to ten lamps. If Messrs Anderson and Munro, by their correspondence, intended to pose as the champions of good work at a remunerative rate, it is unfortunate that they committed themselves to figures. In that part of their letter, however, which does affect the question, they suggest that architects know at once, by a rule of thumb method, what gas jets are required in a building, but have very vague ideas as to the number of electric glow lamps required for the same building. But if an architect is of opinion that fifty gas jets, each of 15 candle-power, are required in a certain sized building, then surely he must also be of opinion that fifty glow lamps, each of 15 candle-power, would be required in the same building; otherwise we are forced to conclude that an architect does not know the amount of light a certain sized burner will give.

Undoubtedly the views set forth by Mr. W. C. Mountain are sound. Why do we not have in every case a regular specification, as has always been the case in engineering? Why is electric lighting to be exempt from the custom and practice of other classes of engineering?

I quite agree with Mr. Mountain that the one and only way out of the difficulty is to place all work in the hands of a consulting engineer. Mr. Sydney F. Walker, in his somewhat verbose communication, draws a parallel between electric engineering and the "red herring and potato" line, which, I think, we may at once dismiss from the discussion if we are to admit that the former has any place among the sciences of the world; neither do I think it fair to suggest that consulting engineers are as a body corrupt or corruptible. In any case, what has proved beneficial in the case of engineering generally ought not be abandoned in the case of electrical engineering. What applies to one equally applies to the other.

There can be no doubt that the "cheap work gentlemen" not only thrive but bring great discredit upon electric enterprise generally, and if the consulting engineer would be the means of getting rid of them, by all means let us have him.

I will give one instance where the contractor managed to get rid of the consulting engineer.

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A party of gentlemen wishing to start a Central Station in their town called in the services of a consulting engineer, who, after carefully going into the whole matter, advised them that it was impossible to charge less than £2 per lamp per annum for glow lamps.

The representative of a well-known touting firm came by, and assured these gentlemen that they would make a handsome profit if 25s. were charged. *The services of the consulting engineer were no longer required.*

I myself, quite recently, was censured for recommending that a depreciation of at least 10 per cent. should be allowed for on the cost of a large installation of engines, boilers and dynamos, when estimating the annual expenses, and was told that nothing ought to be allowed the first year, and about 2½ the second. Here, then, is one chance for wide variations in estimates. Yet another.

Many consider that 50 watts for a 20 candle-power lamp is an outside allowance, and hold it as an axiom that engines of all sizes can be safely loaded to three times their nominal power.

Example: A 4 horse-power nominal engine will indicate 12 horse-power, and, reckoning 10 lamps to the horse-power, will carry 120 lamps! Is there not room, Sir, here for variations in tenders?

The suggestion that a definite standard of illumination for a given space should be adopted by engineers is absurd on the face of it. Does a back kitchen require to be as well lighted as a nobleman's dining room, or, in the case of arc lamps, does a space 100 yards by 100 yards require the same number of lamps as a space 10 yards by 1,000 yards?

We have had enough of vague and meaningless units, pray do not let us add to their number.—Yours, &c.,

J. N. V. MONEY-KENT.

Connaught Mansions, Victoria-street, Westminster, S.W.,
July 20th, 1887.

THE FORBES NON-POLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There seems to be more mystery about the relation of a magnet to its field than I anticipated.

I gather from the letter of Mr. Scattergood that a cylindrical magnet rotated on its axis does not excite a current in a stationary conductor situate in its field, while the conductor itself, if rotated in the same way relatively to the magnet, does give a current. This, too, seems to be the view of Mr. Voice, who endeavours to show that a current is produced in the magnet itself when rotated about its magnetic axis, so that although rotated in its own field it is affected just as if its magnetism did not belong to it. According to these views, therefore, we may consider magnetism to be possessed of *infinite* inertia with regard to rotation about the magnetic axis, at least in all cases in which the field is symmetrical about the axis, as in Forbes's dynamo, and, I suppose, in magnets of different section also. Applying this theory to the case of the Forbes dynamo (I have adopted Mr. Thompson's suggestion), we have a sort of reason for the current generated in its armature, notwithstanding that each point of the armature is throughout its revolution in a field of the same intensity and direction. It also gives us reason to expect that if the armature be fixed and the rest of the machine revolved around it, we shall have no E.M.F. in the armature, but shall have it in the field-magnet, &c., instead.

I am unable to accept this view, for the following reasons:—A current circulating in a coil of many convolutions induces that state of polarisation in surrounding matter which is designated magnetism. We may consider the molecules of this surrounding matter so affected to be polarised in closed chains, enveloping the coil, by a constraining force acting outwards from the coil.

These closed chains of polarised molecules are represented in value and position—of course, not in number—by the conventional "lines of force." When the armature of Forbes's dynamo is rotated the continuity of these chains is broken, and fresh chains of molecules become forthwith polarised, so as to preserve the same aggregate value. The continual rearrangement of the molecules of the conductor involves the production of an E.M.F., and if there be not a path open for a current nothing more, the polarised molecules simply turning over, so to speak, their polarity to fresh sets of molecules, so as to restore the continuity of the chains in their former positions continuously, so that no resistance opposes the motion of the conductor. But if there be an outlet for current the E.M.F. is lowered and the energy is only partly "turned over" as above, so that induction must, in that case, restore the chains, and a mechanical force must be exerted in order to sunder them, the energy thus absorbed appearing as current.

Whether the last sentence or two be correct or not, what does it matter? For whether we rotate the armature or the field-magnet, if there be in each a path open for Foucault or other current, the molecular chains must be sundered by a mechanical force, and why must the whole transformation of the energy take place in either the one or the other alone? I certainly see no reason, unless it is that the *position* of each chain is fixed relatively to that element of the exciting coil from which it springs. But in that case rotation of the coil alone about the magnetic axis would entail rotation of the lines.

I have a strong presentiment that it will be found that what prevents the positions of the lines of force from rotating along with the armature is the powerful retardation due to the generation of Foucault currents by the positions aforesaid cutting through the iron of the field-magnet, &c., their speed of revolution being that at which their motion through the iron of the field-magnet supplies a reaction equal to the pressure of the armature against them, the ratio of energy utilised to that wasted being as the velocity of the positions (lines) through the armature is to their velocity through the magnet.

The problem may be thus definitely stated. May we regard magnetism as possessing infinite inertia with regard to rotation about its axis, according to the views of Mr. Scattergood and Mr. Voice, or is it *quasi* fixed to the exciting coil, so as to be bound to accompany it when rotated (which I take to be Mr. Thompson's view), or is the view expressed in my original letter (*The Electrician*, July 1st), and now repeated, the correct one?—Yours, &c., R. SNOWDON.

Staveley Ironworks, July 20th, 1887.

[CORRESPONDENCE *continued on page 227.*]

THE LIGHTNING RECORD IN GERMANY.—From a recent report by Dr. Hellman on statistics of lightning-damage in Schleswig-Holstein, Baden, and Hesse, it appears that the danger from lightning in these localities (unlike the case of other parts of Germany) has been decreasing of late years. Soft-roofed houses are fired about 7 times oftener than those with hard roofs. Windmills are struck 52 times, and church and clock towers 39 times, oftener than ordinary houses with hard roofs. The marshy regions in Schleswig-Holstein are the most dangerous, and the land about inlets of the east coast the safest. With like conditions, the relative danger decreases the more houses are grouped together. In Baden the danger varies more than in any part of Germany (about Heidelberg it is 24, and in Waldshut 265 per million houses). In Hesse the low plain of the middle Rhine is the most dangerous part. In the fifteen years 1869-83, there were killed by lightning for every million men in Prussia, 4·4; in Baden, 3·8; in France, 3·1; and in Sweden, 3·0. The geological nature of the ground, and especially its capacity for water, has important influence. Thus, calling the danger on lime 1, that for sand is 9, while for loam it is 22. This is partly why most of South Germany and Austria is less dangerous than North Germany. There are four factors affecting the lightning danger to buildings; two physical—unequal frequency of storms, and geological character; and two social—variable population, and mode of building. Of all trees, oaks are most frequently damaged, beeches most rarely (in the ratio 54 to 1).

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p m.

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THE LIGHTING OF THEATRES.

Following up the appalling disaster at the Paris Opera Comique, the *Saturday Review*, with a public spirit which we highly commend, has instituted an inquiry of its own into the condition of the theatres of this metropolis, the results of which are being made known from week to week in the pages of that journal. The thoroughness and fairness of this remarkable series of articles can hardly fail to be the means of effecting many greatly needed improvements in our places of public entertainment. But the inquiry has naturally been directed chiefly to the means of exit in cases of fire, and has done little or nothing towards preventing the prime cause of the outbreak. Of the electric light, the *Saturday Review* Commissioner says hardly anything, except to notify where it is in use; and he is positive only when recommending the employment of oil lamps as an additional security against panic when the gas is extinguished. We shall venture to offer a few observations on these two points presently. But let us see first of all what is the actual state of affairs which this journalistic inquiry has brought to light.

It is no exaggeration to say that not one theatre in a dozen is provided structurally with places of egress adequate to the requirements of a large and widely scattered audience, and recent attempts at improving these shortcomings have generally resulted only in providing doors which are commonly locked, or passages which look like outlets but lead to nowhere. Some theatres which make the greatest parade of their "exits in case of fire" appear to have expended just the price of the labels and no more. If, indeed, the passages over the doors of which these cheerful notices are affixed have any specific object, it would seem to be to accumulate the audience finally all at one point, and jam them there till they are trampled or crushed to death, should they have escaped the suffocation which would certainly overtake those who are stuck fast in the passages behind. Most of these structures have for the great bulk of the audience but one main outlet, to which all or nearly all the other "exits" converge; and in some cases this outlet is frightfully distant from the building, to which it is connected by tortuous windings or dangerous staircases. To these structural hindrances to rapid egress the management usually adds some strong barriers to prevent ugly rushes before the play begins, and which, being kept up all the time the play is on, would assuredly lead to calamity if a frightened audience wanted to get out.

Now, bad as all this is, we are bound to say, after carefully looking at the evidence, that, with the exception of a few obvious reforms, such as the abolition of the vestibules in all theatres, and the absolute closing of some, there is little that can be done structurally to materially remedy the evils complained of. More correctly, we should say, too much would have to be done; for we know from what the *Evening News* says of its interview with the Chairman of the Metropolitan Board of Works that legal action can be taken only when "structural defects can be remedied at a moderate expenditure." Our ideas of safety when most of these theatres were built were different from what they are now; and it would do violence to public opinion were a building condemned, and its owner ruined, because we had neglected our duty in the first instance. Some valuable improvements can still be made, no doubt, at a "moderate expenditure;" and we sincerely hope that the revelations which we owe to the *Saturday Review* will be the means of getting everything done that can be done to mitigate the horrors of a catastrophe from which not even the best constructed theatres can be rendered wholly exempt.

But it is one thing to guard against the consequences of panic, and quite another to prevent the occasion of it. Now the cause is almost invariably fire, and except in very rare instances the cause of the fire is gas. The mere smell of escaping gas has led to the turning of it off at the meter, with the usual consequences to the unfortunate audience. Generally, however, the fire originates in the wings, or somewhere behind the footlights, where there are plenty of naked lights and an abundance of inflammable materials. Not only are the gas-lights a permanent danger, but the gas itself is an additional element of terror. Consequently the first thing done in any case, whether the fire originated with the gas or not, is to turn it off. Permanent oil lamps, as used at some of our best managed theatres, if placed at every suitable spot, would go far to allay the fears of an excited crowd. But oil lamps are troublesome, expensive to maintain in large numbers, and by no means a perfectly safe kind of light. To duplicate or split up the supply of gas would not meet the requirements of an emergency such as we have to guard against; no one would know at the critical moment which source of supply was at fault; and, probably for reasons already adverted to, the whole of it would be instantly extinguished for fear of an explosion.

Here, then, we have the indisputable fact that the employment of gas in theatres is not only almost wholly responsible for the outbreak of fires, but is wholly responsible for the disastrous consequences that ensue. Bad as our theatres are they are not so ill provided with exits as to render escape even for a large audience perfectly practicable if there is light enough

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to guide the men and to pacify the women. But in total darkness even an English crowd could not be trusted to act with fortitude and patience with unseen terrors in front and in rear. It is all very well to multiply outlets, but if the people cannot find them, or cannot see their way when found, the result must be fatal stumblings and a speedy block.

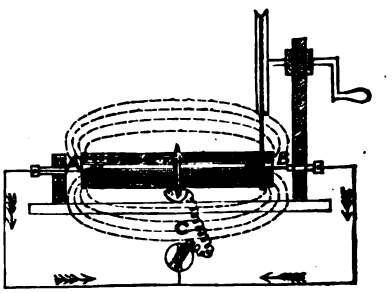
In short, we are led to one broad conclusion, that the best and, indeed, only way to insure the safe exit of both audience and actors in the event of an outbreak of fire is to provide them with a perfectly trustworthy light, which shall neither be itself the cause of fire nor be liable to extinction if a fire break out. We have no knowledge of any mode of lighting, except by electricity, which would fulfil these conditions. We freely admit that even the electric light if carelessly installed might give rise to a serious conflagration; but what we do confidently assert is that it, and it alone, is the light that can be laid on and used with perfect certainty of immunity from this danger, and, moreover, that it can provide the supplementary lights which in all theatres are a proper and desirable safeguard without any risk of extinction whatever. For these safety lamps storage batteries could be charged by the dynamo when not in use for the main system; and no conceivable accident could occur to extinguish both lights at once. An accident to one would be inconvenient, but it would not be fatal; whereas an accident with the gas is almost invariably the beginning of disaster, and is generally the unwitting cause of its horrors being intensified and prolonged.

NON-POLAR OR CORE DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In discussing scientific phenomena, involving as they do natural laws and principles, I think it is undesirable to give special prominence to any particular machine except by way of illustration. For this reason I retain the above title in this correspondence. Whether the word "non-polar" is the best title for this class of dynamos is an open question. I think the second name, as above, would be the best. Mr. Thompson's quotation from Mr. Scattergood's letter would seem to suggest that the latter gentleman is influenced by an out of-date theory. To argue that it is necessary to move a conductor in a varying magnetic field to produce current, or, as the stereotyped phrases go, to add or subtract lines of force, or to increase or diminish the magnetic potential with respect to the movable conductor, by which text books have so long befogged electrical students, is misleading and opposed to facts. It is a positive defect rather than an advantage, but one that cannot be, or has not been, entirely avoided in the construction of dynamos that are required to deliver a comparatively high E.M.F. For that reason this theory has probably been exalted into a "necessity." In a letter to you which appeared on March 8th, 1884, I tried to demonstrate this fact as applied to every known dynamo, both continuous and alternating.

In referring to Weber's experiment, as illustrated in De la Rive's work, and reproduced in a modified form, Fig. 1, in my last letter, Mr. Thompson says:—"When we consider that the collector at the centre (although traversed by a symmetrical field) is under greater inductive influence than that at the end, it is easy to divine the cause of the current." I cannot agree with Mr. Thompson in this. The lines of force, as they go from one pole to the other outside of the magnet, are much more widely distributed and much less concentrated than they are near the poles; and given two conductors of the same area fewer lines would be found to act on the conductor at the middle of the magnet than on that at the pole. However, it is not necessary to have a flange at the pole, as I indicated. Electrical contact may be made at the pivot with like results. For the moment I will accept Mr. Thompson's explanation—which is the same as De la Rive's—in order to analyse it. We will therefore assume the current *is* produced by the rotating magnet and magnetism acting on the conductors unequally. Let the resultant product be represented by 1, while contact is made at the middle and at the pivot A. Under these conditions it will be seen that only one pole or half of the magnet is acted upon. The wire from A may extend any distance in a direction parallel with the axis of the magnet, and will be totally unaffected by the magnetic field, while the other wire will be in the most favourable position to suit Mr. Thompson, and according to his view the current will be produced solely by the lines cutting this one conductor at the equator of the magnet It is understood that the resultant current equals 1. Now, let another conductor be in contact with the other pivot B, and joined to that leading from A, as in the accompanying figure. The speed of the magnet being the same the resultant will now equal 2, just double. Where could this increase of current come from? The number of lines acting on the middle wire in one revolution is the same in both cases, and it is only possible for them to intersect the middle conductor. What will Mr. Thompson say to that? If we regard the magnetism as being stationary while the magnet rotates, and is itself the movable conductor, the double effect is easily understood.



Mr. Thompson goes on to say:—"It is undoubtedly true that in an ordinary dynamo current is produced by the reaction of a condition that itself is instrumental in maintaining." Perhaps I am dull of comprehension, but this passage seems to me to be somewhat vague. I presume he has the self-exciting properties of dynamos in his mind. If so it is a little wide of the question at issue. Do not the armature cores of the Gramme, Siemens, and other continuous current machines revolve at a terrific speed *through* this rigidly fixed though apparently ethereal force? And does not this fact conclusively show that magnetism is separate from and independent of iron? If the lines of force existing between the N. and S. poles of a powerful dynamo are so demonstratively immovable, why should they not be equally immovable in a cylindrical bar magnet? In other words, why should not a cylindrical magnet rotate axially through the magnetism as easily as the Gramme ring revolves longitudinally through it? I say "axially" and "longitudinally" because, in the case of the bar magnet rotating on its axis, the iron molecules move across the polar direction of the magnetism, while in the Gramme ring they move along the polar direction. But it may be said that the magnetism between the two poles of a powerful dynamo emanates from and is held in position by the two field-magnets. Then, does its retention in that position depend on the strength of those magnets? Or, would an excessive power, acting on the magnetism between the two poles, move it from them? In short, is it simply a question of degree as to its fixity or its removal? Existing machines of all sorts and sizes, actuated by varying power, silently bear witness that it is not, but that the magnetism is immovable, although opposed to a force of several horse-power. I will not complicate my argument by alluding to the advanced poles in the revolving Gramme ring.

Mr. Thompson is also of opinion that "the magnet and its field are as intimately connected with each other as the atmosphere and earth of our terrestrial system, and would with as much reason revolve together." I confess I do not quite see the point of this analogy. The atmosphere can be separated into its constituent gases; can be accurately weighed; its pressure calculated and its presence known to us by the

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sense of touch. But we know very little of magnetism—only as it influences other bodies. It apparently has no weight; still its power is exerted through many of the most dense bodies without sensible retardation and without altering its nature.

This mode of obtaining current from a rotating magnet was discovered about fifty-five years ago by Faraday and Weber. Faraday's experiments are not so mechanical and striking as the above simple experiment, although his experiments were more varied and apparently more abstruse. That such a valuable principle should have lain dormant so long can only be because the somewhat elaborate explanation by a philosopher of De la Rive's standing was erroneous, and for that reason its apparent insignificant action was overlooked by subsequent minds.

As it is I venture to prophesy that if certain mechanical difficulties can be overcome, such as taking off the current and getting sufficient E.M.F., the development of this principle will be likely to give a fresh impetus to electrical industries. If Mr. Thompson continues this discussion, I should be glad if he would just notice the reverse action, viz., the rotation of magnets by currents. Perhaps it may help to bear out his views on the subject.

To conclude. By proving the independence of magnetism from the iron in which it may be concentrated, in such a way that one is at rest or fixed in space, while the other rotates, I believe I am justified, by inference, in applying the same law to our terrestrial system. If I may be allowed "to soar into the realms of speculation"—for it does no harm—I am of opinion that magnetism pervades all space, and that it assumes its polar properties only as it is in proximity to bodies that contain iron, such as the earth. Its directive power, viz., that which causes the compass needle to point in a certain direction, is perhaps caused by the distribution of iron in the earth, which may be such as to form a huge magnet, of which the subject matter of this discussion and the enclosed figure is a miniature.

—Yours, &c., E. L. VOICE.

6, Betterton-street, Endell-street, W.C.,
July 17, 1887.

PACKING BATTERIES FOR SHIPMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Through the very bad attention to packing batteries for shipment to the Colonies the breakage is something fearful. I have just unpacked a gross of Leclanché cells and find no less than thirty smashed. I think this matter wants attention in general, and I know of no more sure way of obtaining it than writing you.

The way of packing I would suggest, should be to put not more than twelve cells in separate boxes. If information from this quarter would be of use I shall be glad to forward.

Trusting you will give this publicity.—Yours, &c.,

Brisbane, June 3rd, 1887. JAMES TRACKSON

AN ATTEMPT TO UNDERSTAND THE MATERIAL NATURE OF ELECTRICITY.

BY SAMUEL E. PHILLIPS, F.C.S.

In the schools we are taught, as matter of fact and knowledge rather than of hypothesis, that there is a "luminiferous ether," which not only does miraculous work in space, but, condensed in all the molecules of matter, it affords endless amusement to the metaphysician and physicist.

This hypothesis has met with the severest castigation from some of our ablest writers, and certainly cannot be considered true philosophy. Nevertheless, that there is an all-pervading something which has not been laid hold of by our chemists or biologists is patent in many ways, and the following is an attempt to understand somewhat of its character and mode of working.

The world is an assemblage of atoms of differing properties; with a strict uniformity of these we should inevitably have absolute death, the stillness of equilibrium, and the opposite of that endless change which now constitutes the life of the universe.

Atomic diversity necessarily involves two things—tension and motion. Tension is the expression of static equilibrium, polarity, magnetism; motion is the expression of atomic change, electricity, chemical action. One is the tendency, as the other is its fruition. Each of these fundamental affections admits of a two-fold aspect or division; they are either mechanical or chemical. The distinction is not one of absolute and total separation. Nature has no gaps, no rigid lines of demarcation; hence both these aspects in some cases mingle and coalesce, while in others we have a bold and distinctive separation.

Mechanical tension is the expression of abstract static equilibrium, the foundation of all acoustic phenomena, or another word for elasticity.

Polar tension is the expression of special or linear static equilibrium. If to the former state of particles we superadd the fact of varied atomic force, we get the fundamental idea of elective affinity. Thus, if we place a light gas upon a heavy one, the simple law of mechanical tension would involve a continuance of such relative positions; but a new tension, a linear directive force, is instantly exerted. Nor does the motion and interchange of particles cease until the resultant expression of both forces is fairly established.

On this view of the case, the extended inquiry whether atoms have different properties on different sides seems utterly uncalled for, since we thus inevitably come to the required conclusion in all binary compounds; and the probability is great that the material universe is constituted on a binary type, and that all the metals and gases of elementary chemistry are indeed binary. At any rate, there can be no doubt in regard to the two gases in question that linear directive forces are in operation, and calling the light gas H and the heavy one O, the tendency would be for all the O atoms to point downwards, and, conversely, for the H atoms to point upwards. In such case we may imagine a gaseous magnet with N. and S. sides or ends. Of course the terms north and south are purely empirical, and mean nothing beyond oppositeness; but whether they be negative and positive, or *vice versâ*, is one of the things demanding immediate settlement.

Mechanical motion (within atomic limits) is the propagation of force or impulse in elastic media; thus sound consists of the simple vibrations of any elastic medium, and the lines of force radiate in straight lines upon well known principles.

Polar motion is not a mere vibration to and fro, but an actual change and displacement, a chemical transfer, a something transmitted; whereas, in the propagation of force, it is the abstract affection only that is transmitted. In polar motion the atoms are actually transferred to whatever distance, and such is the case with every form of galvanism or current electricity. Of course an atom liberated at London does not fly to New York, but intermediate atoms are moved or affected in such way that a corresponding atom is liberated at New York

Chemical action is a confused assemblage of small circuits of action, and in most cases a kind of double decomposition.

Galvanic action is the same process, with a definite linear arrangement instead of a confusion of small circuits.

In any case of double decomposition we have the true analogue of all chemical or electrical change. Two binary compounds decompose each other, to a better saturation of electro forces. The action is essentially composed of two halves, or, in other words, is that of a circuit. If an atom of acid tends in one direction, then an atom of alkali reciprocally tends to the opposite, and the tension or momemtum of one is the exact measure or complement of the other. While tension lasts the state is a polar or magnetic one. While motion lasts there is chemical electrical action. And this brings me to my chief assumption, viz., that all chemical action is binary, or, in other words, *that metals conduct by electrolysis.*

It is curious to note the character of modern inquiries as to whether liquids may not in some cases conduct without electrolysis, after the manner of metal wires, &c.

The underlying assumption has long appeared to be both hasty and inconsiderate. We have a polar motion going on

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in two opposite directions, one through the metal, the other through the fluid, and chemical action takes origin at the two terminal junctions. Now, if we, in disregard of all dual principles, attribute the sum of both actions to one half of the physical conditions, then, of course, the other half, being so far degraded, may be considered as a mere passive conductor. But if we would recast our thoughts and take a broader view, it might be well to throw aside the wire complication and suppose the metal area of conduction to be equal to that of the liquid. We thus take one side or half, and for every negative ion O lost or given up by the liquid conductor we have a corresponding positive or metallic ion Zn given up by the metallic conductor or electrolyte, and what takes place at one pole is the perfect antithesis of the other—where the liquid gives up the ion H, and the metal yields the negative or electrical ion E. It is true we have here an element truly hypothetical. Be it so. But then much may be said for the necessity, the force, and simplicity of the assumption.

Whether regarded as an item of force, or of matter, it is very certain that something is wanted before H can be liberated, and equally certain that something does actually pass from the Zn to the H pole. What it is, and the mechanism by which it passes, may be best studied by a generic estimate of the two halves of action upon dual principles.

Cut either side in half and all action is stopped. One is as vital as the other. Starting from the Zn end, O cannot join Zn until its opposite ion is liberated; or, oppositely, Zn cannot combine with O until its opposite ion E is liberated.

But H in travelling to the other pole cannot go through the other particles, and therefore *must* go round them, and hence its spiral course in that direction; and, oppositely, E cannot pass through the atoms of metal, and therefore its spiral course.

It is familiar to every tyro that we have no action without completing the circuit, and that the wire half cannot be completed an instant without the passage of E, evidenced by the weak electrolysis of iodide of potassium or otherwise; but, as in the liquid half, the chain of travelling O's cannot move one tittle without the correlate movement of H in the opposite direction, so we cannot imagine the very weakest electrolysis in the wire half without an equal action in both directions.

The apparent result may depend on the manner in which we estimate the phenomena; for instance, if we insert moistened tanno-gallate paper between points or poles of copper or iron we may then get, as before, certain evidence of the passage of E in the metal half of the circuit. But however common this mode of action in a Bain printing telegraph, yet that it is so far apparently one-sided, and that the metallic half of the function is only concealed, will be evident if we simply invert the terminals in question, the so-called current and all other conditions remaining the same.

Now the passage of E is concealed, and we have apparent *the passage of metal*; the positive iron is actually and visibly transferred. With this change of visible aspect there has been no change of the current phenomena; E passes precisely as before, and we may show it in another part of the circuit. And as in the second case metal passed to a visible ink-making result, so in the first case the action was identical, although the transparent copper may not have been so palpable to observation as the ink-making iron.

It is as curious as it is instructive to rightly understand the action going on in both halves of the circuit. That action is essentially similar in both; both are magnetically neutral in the static condition of rest; both are transversely magnetic during action. But, strange to say—yet we do say it with confidence—*there is no electricity passing through the electrolyte*; the interchange of ME in one half is correlated with a similar interchange of HO in the other; nor is the inductive or magnetic effect in any way due to any individuality of ion. What O does in the circuit may be done with Cl, I, or any electro-negative element; and, conversely, what H does may also be done by a like induction from copper, sodium, or potassium.

Nor does it materially alter things if we entertain the more complex modern notion of + Zn on one side, and the – hypothetical radicle (SO^4) on the other; but in favour of the simpler view we may note that chemists *now* admit that this radical "never has been isolated, nor is it likely that it ever will." And in the modern attempts to measure the *volt* power of a Daniel cell, in terms of the thermal effect of actual combustion, expressed in French calories, it is immaterial whether we calculate the energy of $Zn + O - Cu + O$, or the more roundabout process of $Zn + O + SO^3 - Cu + O + SO^3$. Do we thence infer that sulphuric acid is a non-essential? Far, very far, from it. What we do know is that the oxide of zinc, first formed, would be a non-conducting impediment were it not removed by solution, and the acid otherwise materially augments the conductivity of the badly conducting fluid.

It is an indispensable aid to practical working, but it offers no impediment to the simpler or more abstract view we have taken.

If the prevailing ideas that electricity is a mode of force be correct, then, of course, the views here enunciated are but idle speculations; but let us further and fairly consider the matter.

If the chemical formation of oxide of zinc, or the falling together of ZnO, with its energy of more than 40,000 calories, communicated an atomic shock through the metal half or conductor to the other pole, then it would and must be transmitted in straight lines; and where, then, would be the transverse inductive effects now observed? The hypothesis of mere force is untenable at every point. The idea of communicating force through a wire 1,000 miles long is a wanton absurdity; whereas, if we decompose the binary conditions at one end, it requires no stretch of the imagination to see that this atomic interchange may, nay must, be propagated to any length.

We have seen that force is propagated in straight lines, and when free these are radiant in all directions, so that 10 particles affected at A may excite 100 particles at B with 100th of the potential of those at A. All such forces involve an essentially radiant propagation, while electricity is essentially linear and not radiant. In one case force is propagated; in the other an actual transfer of material particles subsists all along the lines of action. If 10 atoms are affected at A, then only 10 atoms can be affected at B. The lines of force may open out, but in themselves they are not radiant; hence it would be quite possible to electro-plate in New York by means of a battery in London, and for every atom of Zn consumed at one end a corresponding atom of silver or other metal would be deposited at the other.

This leads to the remark that in actual practice we greatly modify the metal half for special purposes by coils, or connecting wires, &c. But in all this there is no departure from the common dual character we have supposed to subsist in two equal halves; only it so happens that copper is an infinitely better conductor of the atomic interchange than water or other fluids.

It is, however, a great mistake to suppose that we can insert wire lengths which conduct otherwise than by electrolysis. In order to see this more plainly let us cut our electrolytic fluid in half and insert a straight tube; we have then the perfect analogue of the wire insertion. There is no visible electrolysis at the points of junction, and it simply conducts like the rest of the fluid; or by inserting a spiral tube the convolutions would increase the inductive effects precisely as in the wire coils used for that purpose. We try our utmost not to diminish the area of fluid on account of the increased resistance; yet we may and do greatly extend the metal part. But in either case the vital fact remains that the entire circuit is strictly limited to and governed by what is taking place at the ends or poles of causation. We know that by polarising a bar of iron, or making it ME ME, elongation takes place, and that by frequent reversals of this polarity the friction of the spirally changing atoms produces heat, as all friction must. And yet, further, that during the moment of interchange a spiral or transverse magnetic induction subsists precisely like that in the battery fluid or wire conductor. But in this case there is no mysterious fluid passing from any battery or electro motor. The ends are free or insulated, and there is only an atomic reversal of position.

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What is now desiderated is that Prof. Tyndall, or some other physicist of like means and abilities, should repeat these demonstrations with a bar of HO instead of ME.

Let us first see the polar condition of water—in fact, the evidence of a water magnet. Secondly, let us see the evidence of heat generated by a continued reversals of its constituents; and thirdly, let us see evidence of the tranverse magnetic effect of its changing particles—in short, magnetic and electrical effects producible without any electricity whatever.

It is not easy at the outset to arrange a voltaic series or linear case of double decomposition totally excluding E from the circuit; *but it will be done.*

In conclusion, what is magnetism, and what is electricity? *Magnetism* is a binary polarity of atoms; it is a static polar tension, and the influence is communicable by induction through all media. As we have good and bad conductors of light, heat, sound, or electricity, &c., so different media have their special capacities for the conduction of polar force.

A non-recognition of this plain and simple fact has greatly vitiated the modern researches on diamagnetism, and in some sense all the philosophical and mathematical developments are a great mistake; but while these researches have reference to a new force, which to me has no existence, still there has resulted from such great endeavours a vast body of new and valuable facts in illustration of the laws of conduction for polar force, and Faraday's "Researches" will long be appealed to as one of the most valuable text books in a new field of interest and value. Magnetism, or polarity, is, then, the expression of opposite properties on opposite sides. A bar of iron may thus be made to have positive or negative poles; but when the constraining power is removed the mobility of particles is such that they tend to equilibrium; while in the case of steel the rigidity of particles tends to a continuance of the binary tension in what we call a permanent magnet.

What, then, is electricity? It is polar motion, it is a continuance of that spiral interchange we have seen indicated in a reversed magnetic bar. As magnetism is polar tension, so electricity is polar motion. One is static as the other is dynamic. The all-pervading ethereal element, electron, electrine, or æther, is most commonly involved in the phenomena, but not necessarily, and whatever effects may be produced by ME, may also be referable to HO.

The simple or abstract view we have taken of battery action or of electrolysis may be true or it may not, but a lifelong study of the practice and theory of electricity prompts me to regard it as essentially, or in the main, a valid conception. But of apparently contradictory facts and varied complexities there is no end.

Our modern batteries do not derive more than half their power from the zinc consumption of the positive poles. Both sides or poles of the circuit are made to contribute to an augmented potential. These are varieties of detail which do not disturb the fundamental principles of action; and there is great danger in modern ways of becoming too clever, or getting lost in the multiplicity of facts and details.

If our simple view be scarcely recognisable in the books, it is much less so in the extended papers of modern electricians, where Helmholtz, Oliver Lodge, and others see opposite electrolytic ions travelling at different rates, and many other complexities which seem defiant of plain dual principles. But, alas! these are matters which can only be appreciated by a select few endowed with the highest attainments of modern education.

Which, then, is best? Should the great majority be silent and lose all manly independence in the cry "Great is Diana of the Ephesians!" or should they elect to make parallel efforts of equal magnitude in the prosecution of sound first principles with common sense reasonings, where both aspects might certainly render mutual aid?

Of the great abilities and love of truth of the eminent few there can be no doubt or question whatever; but Nature is impartial, and will best respond to those who seek her with humility and intelligence.

P.S.—It is, perhaps, right to add that between the hypotheses of mere force and electrolysis, Mr. Sprague, whose general views so closely accord with my own, has another hypothesis by which any idea of actual or material electricity is unnecessary; but his view is more hypothetic than mine, and has the disadvantage of being a special hypothesis rather than a general one.

He endorses my view of the liquid half, but on the metal side he thinks that the atoms turn round upon their neutral axes *without progression*, while in the liquid half the ions turn round, or exchange places *with progression.*

It is fair to consider that the same element may take part in both sides of the reaction, as with copper to wit; but how different must be the functions involved. In one case Cu is a + ion in connection with its − correlate; in the other it is both + and − in one, and turning round on its neutral axis.

But however incongruous this hypothesis may appear on further examination, yet many may prefer it as being more orthodox, with its two kinds of conduction, one with electrolysis, the other without. But time and further experiment will probably decide which is best in accordance with the truth.

P.S. 2—That electricity is in principle as material as water I have often contended in these pages, but Mr. Carl Hering, writing to the *Electrical World*, has expressed the fact with much of clearness and force. He says, "It is a well known fact that quantity of electricity measured in coulombs never is generated, never is consumed, and never does grow less, excepting leakage. The current flowing out of a lamp is exactly the same in quantity as that going into it; the same is true of motors and of generators, showing that electricity of itself is neither consumed while doing work nor is it generated. After doing work in a lamp or motor, it comes out in precisely the same quanoity as it entered. A battery is not able to generate quantity or coulombs of electricity, all it is able to do is to take the quantity which pours in at one pole, and sends out at the other pole with an increased pressure, or E.M.F. Electricity, therefore, is not merely force (or a form of energy), but matter. It is precisely analogous to water in a water circuit. The water is neither consumed nor generated. The pump merely increases the pressure of the water which flows in at one end. The water motor merely consumes the pressure, and converts it into mechanical work of another kind. It does not consume the water. The quantity of water, measured in units of quantity, is the same in all parts of a closed circuit of water, &c."

STUDENTS' CONVERSAZIONE AT THE FINSBURY TECHNICAL COLLEGE.

The *conversazione* given by the students at Finsbury Technical College on Friday evening last was attended by over 400 visitors, and proved to be a most successful and enjoyable affair. The building had been tastefully decorated throughout, and a large fountain illuminated by coloured arc and incandescent lamps played at the foot of the staircase. At eight o'clock Prof. Ayrton, F.R.S., delivered a most interesting and instructive lecture upon "Church Bells." It would, perhaps, have been difficult to have hit upon a subject better suited for such an occasion, and the numerous experiments—winding up with a charming performance by Mrs. Ayrton upon an instrument of the psaltery, sackbut, or dulcimer type—evoked great enthusiasm. At half-past nine o'clock this was followed by an equally interesting but somewhat more technical lecture on "Spectrum Analysis," by Prof. Meldola, F.R.S. By the aid of an electrical lantern some magnificent screen projections were displayed, the brilliancy of the effect greatly delighting the audience. In the meanwhile, in the second lecture hall an excellent musical programme was proceeding, which might also be heard by telephone in a distant part of the building. Those who sought instruction in preference to or in combination with amusement were also amply catered for. Mr. W. E. Sumpner, B.Sc. (a former student of the college, who has recently come prominently before the scientific world through his investigations on self and mutual induction), expounded and illustrated the use of the secohmeter.

The display of physical and chemical apparatus in the laboratories was of a most extensive character. Confining ourselves only to the electrical section, in addition to the large collection belonging to the College, the following companies and firms had sent exhibits, and we much regret that the limits of our space do not permit us to do more than catalogue their names:—The Gulcher Electric Lighting Company, Woodhouse and Rawson, Paterson and Cooper, Nalder Brothers and Co., Elliott Brothers, the Electrical Power and Storage Company, Shippey Brothers, Mark Bailey and Co., Goolden and Trotter, J. G. Statter and Co., Faraday and Son, Julius Sax, the Electrical Apparatus Company, Mayfield, Rogers, the General Electric Apparatus Company, A. Slatter and Co., Hodd and Co., and Hersch, Pritchard and Co. In conclusion, we must not omit to mention the "Trade" classes,

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who exhibited some very creditable work, as did also the College Photographic Society. Altogether the display well exemplified the extent and importance of the work carried on at the institution, and all concerned are to be congratulated upon the eminently successful character of the results attained.

THE MEASUREMENT OF SELF-INDUCTION, MUTUAL INDUCTION, AND CAPACITY.

BY W. E. SUMPNER, B.SC.

(Concluded from page 213.)

SOME FURTHER RELATIONS BETWEEN THE NETWORK FUNCTIONS.

In the simple case of the Wheatstone bridge many relations follow from Lord Rayleigh's* theorem that if the current in any arm s of the bridge be C_s, and if $s+\sigma$ is the value of s for which the bridge will be balanced, the current through any branch of the bridge will be exactly as if the resistance s were increased to $s+\sigma$, provided we introduce into the new arm $(s+\sigma)$ an electromotive force $C_s\,\sigma$ acting in the direction of the current C_s.

Indeed, from the general fact that $\frac{R_{xy}}{R_{xz}}$ is independent of x, it follows that

$$\frac{R_{ss}}{R'_{ss}}=\frac{R_{sq}}{R'_{sq}}=\frac{R_{sb}}{R'_{sb}}=\frac{R_{sp}}{R'_{sp}}=\frac{R_{sq}}{R'_{sq}}=\frac{R_{sr}}{R'_{sr}},$$

where the quantities with a dash denote the corresponding quantities without a dash after we have substituted $s+\sigma$ for s in them.

Also, each of the above expressions is equal to $\frac{\Delta}{\Delta'}$, since

$$\Delta'=\Delta+\sigma B,$$

where

$$R_{ss}=\frac{\Delta}{B} \text{ and } R'_{ss}=\frac{\Delta'}{B}.$$

Moreover, for the Wheatstone bridge we know

$$R_{gb}=\frac{\Delta}{p\sigma} \qquad R'_{gb}=\infty$$

$$\therefore \frac{p\sigma}{\Delta}=\frac{1}{R_{gb}}=\frac{\sigma}{R_{sb}}\cdot\frac{1}{R'_{sg}}=\frac{\sigma}{R_{sg}}\cdot\frac{1}{R'_{sb}}$$

by the above-mentioned theorem.

It follows that Δ' breaks into factors—a fact easily verified, and one the statement of which is equivalent to Lord Rayleigh's theorem

$$\Delta'=p\,R'_{sg}\,R'_{sb},$$

or

$$p\Delta'=\Delta'_{sg}\,\Delta'_{sb}.$$

The same theorem gives—

$$\frac{1}{R_{sg}}=\frac{1}{R'_{sg}}+\frac{\sigma}{R_{ss}\,R'_{sg}}=\frac{1}{R'_{sg}}+\frac{\sigma}{R_{sg}}\frac{1}{R'_{ss}},$$

$$\frac{1}{R_{sb}}=\frac{1}{R'_{sb}}+\frac{\sigma}{R_{sb}}\frac{1}{R'_{ss}}=\frac{1}{R'_{sb}}\left(1+\frac{\sigma}{R_{ss}}\right),$$

$$\frac{\Delta'}{\Delta}=1+\frac{\sigma}{R_{ss}}=\frac{1}{1-\frac{\sigma}{R'_{ss}}},$$

$$\frac{1}{R_{bb}}=\frac{1}{R'_{bb}}+\frac{\sigma}{R_{bs}}\frac{1}{R'_{bs}};$$

and other relations can be written down.

The theorem stated above can be proved and generalised as follows:—

Let s be the resistance of any branch of any network of conductors; let E_s be the electromotive force, C_s the current, and V_s the difference of potentials of the extremities of the branch s. Suppose that E_s and V_s both tend to maintain the current C Then

$$s\,C_s=V_s+E_s.$$

If we have a second network which differs from the first only in the branch s we shall have

$$s'\,C'_s=V'_s+E'_s,$$

where, by supposition, $V_s=V'_s$, $C_s=C'_s$. This can only be the case when

$$E'_s-E_s=(s'-s)C_s.$$

If this relation holds, and if the resistances and electromotive forces of the second network differ only in the branch s, we shall have

$$V'_s-V_s=s'(C'_s-C_s).$$

If $C'_s=C_s$, the currents in corresponding parts of the two networks will be the same, for V_s and C_s being known the currents in the network outside s are perfectly determinate, and will be the same for the two cases if V_s and C_s are so.

Now suppose the change to take place in two parts.

First alter the electromotive force E_s: the current changes according to the equation

$$C''_s-C_s=\frac{E''_s}{R''_{ss}}-\frac{E_s}{R_{ss}},$$

since the change is entirely due to the change of the electromotive force E_s;

and

$$E''_s-E_s=R''_{ss}(C''_{ss}-C_s),$$

since

$$R''_{ss}=R_{ss}, \text{ by supposition.}$$

* "Determination of B.A. Unit," *Phil. Trans*, Part II., 1882, page 677.

Now suppose s be changed to s', so that R''_{ss} is changed to R'_{ss}, where $R'_{ss}-R''_{ss}=s'-s$: we have

$$C'_s-C''_s=\Sigma\frac{E_x}{R'_{xs}}-\Sigma\frac{E_x}{R''_{xs}}$$

$$=\Sigma\frac{E_x}{R'_{xs}}\left(1-\frac{R'_{xs}}{R''_{xs}}\right)=\Sigma\frac{E_x}{R'_{xs}}\left(1-\frac{R'_{ss}}{R''_{ss}}\right)$$

by (10); or

$$C'_s-C''_s=C'_s\left(1-\frac{R'_{ss}}{R''_{ss}}\right);$$

that is,

$$R''_{ss}\,C''_s=R'_{ss}\,C'_s.$$

Now suppose that $E''_s-E_s=(s'-s)C_s$:

then $E''_s-E_s=(R'_{ss}-R''_{ss})C_s$;

but $E''_s-E_s=R''_{ss}(C''_{ss}-C_s)$;

whence

$$R''_{ss}\,C''_{ss}=R'_{ss}\,C_s$$

$$=R'_{ss}\,C'_s,$$

or

$$C'_s=C_s.$$

Thus, if C_s be the current in any branch of any network of conductors, and if the resistance s of the branch be increased to s', the currents will be the same in every part of the network, provided an additional electromotive force be inserted in the branch s aiding the current and equal in amount to

$$(s'-s)\,C_s.$$

This is expressed analytically by the equation

$$\frac{1}{R_{xy}}=\frac{1}{R'_{xy}}+\frac{s'-s}{R_{xs}R'_{ys}} \qquad \ldots\ldots\ldots \quad (19)$$

x, y, s are any three branches of the network, any two or all three of which may be identical.

EXAMPLES.

Consider Maxwell's method of determining capacity (Vol. II., sec. 776). Suppose the commutator be placed in the arm s of the bridge. By equation (3) the formula is

$$\frac{E\,t}{R_{bg}}=2\,K\,V\left[\frac{s}{R_{sg}}\right]_{s=\infty}$$

where V is the highest potential to which the condenser rises. Now

$$V=\left[s\,C_s\right]_{s=\infty}=\left[\frac{s\,E}{R_{bs}}\right]_{s=\infty}$$

since this is the potential difference of the condenser when the commutator does not revolve. The derangement from balance is $\sigma=s'-s$, where $s'\,p=q\,r$; whence

$$\frac{1}{R_{sg}}=\frac{\Delta'}{\Delta}\frac{1}{R'_{sg}} \qquad \frac{1}{R_{sb}}=\frac{\Delta'}{\Delta}\frac{1}{R'_{sb}}.$$

Now

$$\frac{\Delta'}{\Delta}=\frac{1}{1-\frac{\sigma}{R'_{ss}}}=\left(1+\frac{\sigma}{R_{ss}}\right);$$

whence

$$\frac{t}{R_{bg}}=\frac{2\,K}{R'_{sg}\,R'_{sb}}\times\left[\frac{s^2}{\left(1-\frac{\sigma}{R'_{ss}}\right)^2}\right]_{s=\infty}=\frac{2\,K}{R'_{sg}\,R'_{sb}}(R'_{ss})^2.$$

Now

$$\frac{1}{R_{bg}}=\frac{1}{R'_{sg}}\left[\frac{s}{R_{sb}}\right]_{s=\infty}=\frac{R'_{ss}}{R'_{sg}\,R'_{sb}}.$$

Substitute, and we get

$$K=\frac{t}{2\,R'_{ss}}=\frac{t}{2}\frac{\text{coefficient of } s' \text{ in } \Delta'}{\Delta'},$$

which is Maxwell's solution.

By writing out the value of R'_{ss} as above defined, and remembering that Δ' breaks into factors, this formula will be found identical with that given by Professor J. J. Thomson.

Self induction of the galvanometer has no effect whether the condenser gets fully charged or not. Professor Ayrton has noticed the misprint of a for α in Maxwell (Vol. II., sec. 776).

As another example, take Ayrton and Perry's method of determining self and mutual induction.

Integrating equation (2), during the time t that the galvanometer and battery are on together we have in this case

$$Q_1=\frac{E\,t}{R_{bg}}-\frac{1}{R_{sg}}\left\{\frac{E\,L_s}{R_{sb}}+\frac{E\,M_{sb}}{R_{bb}}\right\}-\frac{1}{R_{bg}}\left\{\frac{E\,L_b}{R_{bb}}+\frac{E\,M_{sb}}{R_{bs}}\right\}-\frac{1}{R_{gg}}\frac{E\,L_g}{R_{bg}}.$$

While the galvanometer is short-circuited the additional quantity which rushes through is

$$Q_2=+\frac{1}{g}\frac{E\,L_g}{R_{bg}},$$

since g is the new value of R_{gg}. Thus the quantity Q_1-Q_2 passing through the galvanometer in each cycle is zero if

$$t+\frac{L_g}{g}-\frac{L_g}{R_{gg}}-\frac{L_b}{R_{bb}}-\frac{M_{sb}}{R_{sb}}=\frac{R_{bg}}{R_{sg}R_{sb}}L_s+\frac{R_{bg}}{R_{sg}R_{bb}}M_{sb}.$$

Now

$$\frac{R_{bg}}{R_{sg}\,R_{sb}}=\frac{R_{bs}\,R'_{sg}}{R_{sg}\,R_{sb}}\frac{1}{\sigma}=\frac{R'_{sg}}{\sigma\,R_{sg}}=\frac{\Delta'}{\sigma\,\Delta}=\frac{1+\frac{\sigma}{R_{ss}}}{\sigma}$$

since

$$\frac{1}{R_{bg}}=\frac{\sigma}{R_{bs}\,R'_{sg}};$$

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moreover, $$\frac{R_{bg}}{R_{sg}R_{bb}} = \frac{1}{\sigma}\frac{R_{bs}R'_{sg}}{R_{bb}R_{sg}} = \frac{\Delta'}{\Delta\sigma}\left\{\frac{R_{bs}}{R'_{bb}} + \sigma\frac{R_{bs}}{R_{bs}R'_{bs}}\right\}$$
$$= \frac{1}{\sigma}\left\{\frac{R'_{bs}}{R'_{bb}} + \frac{\sigma}{R_{bs}}\right\} = \frac{1}{\sigma}\left\{\frac{p+r}{p} + \frac{\sigma}{R_{bs}}\right\};$$

whence we obtain

$$L + \frac{p+r}{p}M_{sb} = \sigma t + \sigma\left\{\frac{L_{sg}}{g} - \frac{L_{sg}}{R_{gg}} - \frac{L_b}{R_{bb}} - \frac{L_s}{R_{ss}} - \frac{2M_{sb}}{R_{sb}}\right\}.$$

This solution is identical with that worked out in Ayrton and Perry's paper.

For the method indicated by Fig. 17 we have, if X be joined to C,

$$Q_e = \frac{Et}{R_{bg}} \qquad Q_p = \frac{M_{rb}E}{R_{bb}R_{rg}} + \frac{M_{rb}E}{R_{bg}R_{br}} - \frac{L_{sg}E}{R_{bg}R_{gg}} - \frac{L_{sg}E}{gR_{bg}},$$

where t is the time in a cycle during which the galvanometer and battery are on together. We get for balance

$$\frac{s+q}{s}M_{rb} = -(p+r)t - (p+r)\left(\frac{L_{sg}}{g} - \frac{L_{sg}}{R_{gg}} - \frac{2M_{rb}}{R_{rb}}\right)$$

and indeed this formula might have been deducted from the preceding, since the derangement from balance is

$$-(p+r).$$

For the method indicated in Fig. 18 we have, in the case where r is infinite,

$$Q_e + Q_k = \frac{Et_1}{R_{bg}} + KE\rho_1\left(\frac{b_2}{R_{bb}} + \frac{g}{R_{bg}}\right),$$

where t_1 is the time of charging;

$$Q_e + Q_k = \frac{Et_2}{R_{bg}} - KE\rho_2\left(\frac{b_2}{R_{bb}} + \frac{g}{R_{bg}}\right),$$

where t_2 is the time of discharging. The whole quantity is zero if

$$t_1 + t_2 = K(\rho_2 - \rho_1)\left\{b_2\frac{s+q+g}{s} + g\right\},$$

where, if we imagine the condenser replaced by a battery, the proportion of the current through the galvanometer to that through the battery will be ρ_1 when the free end of the battery is connected with the wire b_2, and ρ_2 when it is connected with the galvanometer. Now, generally, s will be small compared with b_2 or with q, so that ρ_1 may be neglected compared with ρ_2, and

$$\rho_2 = \frac{s+q}{g+s+q}, \text{ practically;}$$

so that

$$K = \frac{s}{qb_2}t,$$

where t is the period of the commutator.

If a vibrating tuning fork be used to commutate the connections t will be very small, and the formula must be more fully worked out.

For the case of Fig. 9, when the resistance s is infinite, we have for balance the condition

$$\frac{Et}{R_{bg}} = KV\left[\frac{s}{R_{sg}}\right]_{s=\infty}$$

neglecting the self-induction of the galvanometer, V being the potential difference to which the condenser rises, and, as before,

$$V = \left[sC_s\right]_{s=\infty} = E\left[\frac{s}{R_{sb}}\right]_{s=\infty}$$

and, as in Clerk Maxwell's method, we get

$$t = KR'_{ss};$$

in fact, the method is essentially the same as that of Maxwell. Its connection with Maxwell's method of determining self-induction (see Fig. 7) is clearly shown by deducing one formula from the other.

We have for self-induction—

$$L_s = \frac{qr - ps}{p}\left(t + \frac{L_{sg}}{g} - \frac{L_{sg}}{R_{gg}} - \frac{L_{ss}}{R_{ss}}\right);$$

we have for capacity—

$$-s^2K_s = \frac{qr - ps}{p}\left(t + \frac{L_{sg}}{g} - \frac{L_g}{R_{gg}} + \frac{s^2K_s}{R_{ss}}\right).$$

Now $R_{ss} = s + R_{os} = s + R_2$, using Maxwell's notation;

also, $$\frac{ps - qr}{p} = s - R_1 \qquad ,, \qquad ,,$$

whence $$\frac{s^2K_s}{(s-R_1)(s+R_2)}(R_1+R_2) = t + \frac{L_{sg}}{g} - \frac{L_g}{R_{gg}}.$$

Now make s infinite, and we have

$$K_s(R_1+R_2) = t + L_{sg}\left(\frac{1}{g} - \frac{1}{R_{gg}}\right).$$

The foregoing examples are sufficient to show the ease with which the solutions of network problems may be obtained in terms of the resistance functions. For such problems these functions possess the same two advantages over determinants that determinants possess over common symbols. The first is that complex quantities are expressed in a simple way and analysis is rendered more rapid. The second is that if the solution is of a simple nature it must be possible to eliminate the complex quantities by making use of the relations between them, while if the solution is complex all that can be gained is the power of expressing the result in a simple manner.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The thirtieth half-yearly general meeting of the shareholders of this Company was held on Thursday, July 14th, 1887, under the presidency of John Pender, Esq.

The SECRETARY read the notice convening this meeting, and the minutes of the last general meeting.

The CHAIRMAN: Gentlemen, before asking you to approve of the accounts I will, as usual, make some remarks upon them and upon the business of the last half year. The revenue for the six months ending on the 31st March, 1887, amounted to £331,862, against £341,405, or a decrease of £9,543. The balance brought forward from last half year's accounts is £19,458 less than in 1886, so that we now have to deal with the sum of £28,902 less than at this time last year. The total working expenses amounted to £33,035, against £92,241, or a decrease of £9,209. This, in a measure, arises from the absence of those extraordinary expenses which are unavoidable in time of war. The general expenses in London were £8,169, against £8,773, or a decrease of £604. The principal decreases took place in office expenses, rent, taxes, lighting, stationery and printing, and repairs of furniture. Working expenses at the stations were £60,674, against £64,439. Most of the items under this head show a considerable decrease, the net reductions in station expenses, as compared with the corresponding period of 1886, being £3,765. The expenses attending the repairs and renewals of cables were £43,903, against £41,637, or an increase of £2,266. One of the items in this account is for the completion of the repairs to the Direct Lisbon cable, which is now nearly entirely new. One of the Company's ships, the screw steamer "John Pender," has been fitted with new boilers, improved electric light, thoroughly overhauled and re-classed at Lloyd's. The expenses of carrying out this work, together with the extensive alterations made to the hull, and picking up the gear, &c., of the unfortunate screw steamer "Volta," has been charged to the maintenance ships fund. We have laid in the last six months 135 miles of new cable. Notwithstanding the reductions in revenue to which I have referred, it is satisfactory to find that after charging all expenses, including income-tax, providing for interest on debentures, debenture stock and preference shares, we are still able to pay a dividend and bonus on the ordinary shares at the rate of 5½ per cent. for the year, and to carry forward £48,000 to the general reserve fund. Gentlemen, these are the main and striking points in the accounts, and I shall now give you some general remarks upon what has occurred since I had the pleasure of addressing you in January. When I then had the pleasure of addressing you we had been paying a bonus for some two or three years. I stated that the reductions which were forced upon us at Berlin took away something like £40,000, and that that practically did away with our bonus. I think I shadowed forth at the same time that in all probability—believing that there was a recouping influence at work in our telegraph system—we hoped that the year would not pass without, at any rate, our paying some portion, if not all, of the bonus. Singularly, during the first few months of the reduction in the rates, instead of there being an increase in our traffic it rather went back. However, that was temporary, and I am glad to say that in the last two or three months things have come right again, and that we are enabled to-day to redeem my promise, because for the last half-year we are going to pay you the usual bonus, which has been at the rate of ½ per cent. for the six months. I hope this will be satisfactory to the body of shareholders. It ought to be satisfactory in this, that while we have met a large public demand for lower rates, we have returned to paying our shareholders what we believe they are very fairly and honestly entitled to—a bonus in this great and important enterprise. I think you will admit that this, upon the whole, is a satisfactory statement.

Since I last had the pleasure of addressing you we have connected Tangiers with our cable system at Gibraltar. We found there was a great public want required there. We were requested to do this work, and we did it, and I am very glad to say that it has proved a satisfactory connection. The cable is working well, and the return is much in advance of what we anticipated. That is another feeder to this great system, which will bring in a few thousands a year. The Italian Government have also, under our more immediate eye, laid a cable from Massowah and Assab, connecting it with our station at Perim. That will be an additional feeder to our system. That has also been been satisfactory. We undertook to protect it for three months, I think, and we got about £5,000 for doing the work. It is very satisfactory for me to tell you that there was no work required from us.

There is a further important question which I shadowed forth on the last occasion of our meeting. I said that to make ourselves thoroughly independent of our land line system through France it might be necessary to lay another cable from the Land's End to Gibraltar and Malta. Looking to the state of affairs on the Continent, probably we have not undertaken to do this work one day too soon. Anybody reading *The Times* of to-day must have been struck with the critical position in which Europe is at the present moment. It has always been the policy of your Board to be ahead in their work—that is to say, we are free to act, and we believe we have the support of our shareholders in thus acting as long as we can see our way to maintain our dividend. We see our way in doing this work to saddle the undertaking with but a very slight additional amount of capital, and we say that the independence that will give us for maintaining our dividend is a result which justifies us in doing this work. We have had a line through France for some years, and we have occupied that line very considerably. We have felt that it was not a safe line to rely upon. We have had difficulties thrown in our way on the part of the French Government to renewing that concession. We thought it was well, therefore, to take time by the forelock. Although we have applied to our Government to assist us in this work we

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have only had the response that at the moment, so far as they were concerned, it was not considered necessary. However, we have before anticipated the wants of the Government, and we believe we are anticipating the wants of the Government and of the nation at the present moment, and in doing so I believe we are adding immensely to the stability and position of this telegraph company. That line will be laid and working within the next two months. It may be laid sooner if desired, and it will secure to us, should any interruption take place in our French system to-morrow, all that we at present obtain by our line through France. It will also secure to us a great addition to our carrying power, which is required from the reduction of rates which is taking place now, and which is likely to take place all over the world. As I have said before, our policy is to be ahead, not behind, the wants of the country and of telegraph people, and I can safely say that in carrying out this cable we are carrying out the policy which has made the Company what it is at the present moment—a Company so strong in itself that I believe it is impossible to attack it in any way on the ground that we are not doing our work efficiently and well. I have told you a straight story about this work. We have intimated to our Government that if at any time they require a preferential working of that cable—and I believe the time may come when they will require it—what they will have to pay for it. I think what we have done will commend itself to the Government, as I am pleased to find it commends itself to our shareholders.

We have had during the last six months a very melancholy event. We have lost another steamer, and we cannot understand how that loss could possibly have taken place. It can only be on the plea that the captain and officers of this ship "Volta" were so accustomed to sailing among the islands of the Greek Archipelago that they had got to believe the ship could take care of itself. The captain has gone, he did his work admirably for us, and how he made such a mistake in taking his vessel on the rocks instead of taking her through the proper channel I cannot understand. However, I am pleased to tell you that the Board of Trade, having made a very careful inquiry, have relieved the Company from all blame. We are not held in any way responsible for the act. The ship was reported by the Board of Trade to have been in the most efficient condition. There is nothing wanting in our ships to do our work well, and while we were complimented by the Board of Trade on the efficiency of that ship our captain was evidently at fault. It has resulted in no pecuniary loss to the Company. The insurance money has paid for the new ship we are now building to replace the vessel that has been lost. All possible modern improvements will be introduced, and I hope we are acquiring a ship that will work probably more economically than the one which we have just lost.

There is another question which it is right I should mention, that is, we are replacing our 5 per cent. debentures, which expire on the 1st of August next, by a 4 per cent. stock. I am glad to say that that has been pretty freely taken up by those who hold our 5 per cent debentures. This will effect a certain saving to the Company. But it does more than effect a saving; it shows the solid position in which this Company is considered to be by the investing public. I think from the early days—and this is the 30th half-yearly meeting, I believe, that I have addressed—I have always said that this was a property the importance and value of which we had yet to learn. Every year has taught us that we control it and command it. If a fault occurs to-day, within a few days we may say almost to a certainty that that fault will be repaired. Therefore, we have established what now may be called a permanent property, and it is being so viewed when this 4 per cent. debenture stock is being so freely taken up. I think that is a compliment to the Company. I am glad to find that not only is our property good as to our cables, but I believe that our credit is equally good. I may say that should there be any amount of this 4 per cent. stock not taken up by those who hold the 5 per cent. debentues, or if there are any parties who do not hold those debentures and who wish to take this stock will send in their names, we will consider the applications they make for any portion of the stock not taken up by the holders of the present debentures. I would just, in closing these remarks, refer to this great year in the history of England—the Jubilee of the Queen. I may say, in regard to this period of 50 years, that it is during the last 20 years that submarine telegraphy has been established and brought up to its present position; and probably nothing has been done during the reign of Her Majesty that has left a greater mark upon human progress than this submarine system of telegraphy. People talk of confederation. I say that this system has been the means of bringing about a great moral confederation. It has brought our colonies and the mother country into daily, almost hourly, communication, and the result is that we find throughout our colonies an amount of loyalty—aye, loyalty exceeding that which we see at home. I think we may congratulate ourselves as a company on the great work we have done, and I trust that that work will continue, and that when the days of war scares come round the telegraph will play an important part in preventing war, and that if war does occur it will play a still more important work in bringing it to a close. With these remarks I beg to move the following resolution:—

"*That the printed report and accounts of the Directors to the 31st March, 1887, submitted to this meeting be, and the same are hereby received and adopted; that a dividend on the preference shares of the Company to the 30th June, 1887, at the rate of 6 per cent. per annum be paid, less income-tax, and that, in accordance with the Directors' recommendation, a dividend be and is now declared of 2s. 6d. per share, with a bonus of 1s. per share, both free of income-tax, on the ordinary shares of the Company, making, with previous payments by way of dividend on account, a total payment of 5½ per cent. on these shares for the year ended 31st March, 1887.*"

Mr. G. G. NICOL: I beg to second that.

The CHAIRMAN: If any gentlemen desires to put any question to me, or make any remarks on the report, I shall be very glad to hear him before I put the resolution.

Mr. JOHN NEWTON: May I ask a question? Would you mind telling us what is the difference in the security between the five per cent. debentures and the stock which the holders have now the option of exchanging for? We naturally look for a higher security, seeing that we are going to take a step lower in the rate of interest payable. Do you mind telling us how many debentures have been exchanged up to the present time?

The CHAIRMAN: I think, Mr. Newton, there is no use in dealing with a half-finished job. I shall be able as soon as the time expires to tell you. We have given a time, after which applications by the debenture holders to make the exchange for this new stock must cease. That time is the 16th of July, and I will then tell you exactly how we stand in that matter. As to the security, the new security is precisely the same as that which it is taking the place of. The solicitor corrects me. The new security is to be a permanent security. The other one was a terminable security, and the permanent security will be a first charge upon the Company's undertaking. As I have often said to you, in all these matters we are guided by precedents, and we are also guided by the reports of our solicitors and accountants. If you wish for any further information on the subject—what I call technical information—Mr. Burt will be very glad to tell you exactly what the security is; but I think I have given you pretty well the gist of it.

The SOLICITOR: I think it would be satisfactory to all the shareholders if I were to answer Mr. Newton's question in a little more detail. The present security of the debenture holders is simply a bond or obligation of the Company to pay the money at the time named. It is a fixed date, and the Company has to pay that sum at that fixed date, but it has no charge upon the property or revenues of the Company—no specific charge. It is an obligation, a debt, of the Company, but it is not a specific charge on the property. With respect to the mortgage debenture stock, which, as Mr. Newton says, is 4 per cent., the debentures bearing 5 per cent., that is expressly made a first charge on the undertaking and property of the Company. The special resolution expressly says, "That the Board of Directors be and are hereby authorised from time to time to create and issue mortgage debenture stock of the Company to an amount not exceeding one-third of the share capital of the Company for the time being issued and paid up, upon the terms that the aggregate amount of the said stock for the time being in issue, and the interest thereon, shall rank *pari passu* as a first charge on the undertaking and revenue of the Company." Therefore the holders of mortgage debenture stock do have a settled and higher class of security than the holders of the debentures. The interest, as Mr. Newton says, is less, but the security of both, I think, is very ample.

Mr. NEWTON: The answer which the solicitor has given I am very much obliged for. I think it is necessary when a company is issuing any kind of bond or security to which they attach the word "mortgage" it should be explicitly understood by the investor. It is by using such terms as that when there is no mortgage that the public are deceived. I have a security now in another company where the term "mortgage" is used, and it is no mortgage at all. Seeing the correspondence in the papers recently in reference to these first charges, calling them mortgages, it is an advantage to this Company to say what is the exact security offered to those who are probably putting trust money in this property. I have held these 5 per cent. debentures since they were issued, and I have been very pleased with my security. While I am pleased to see telegraph property ranking as it ought to have ranked years ago, I do not, as an individual investor, like to go from 5 per cent. to 4 per cent. without the fullest information. I thank you for your information.

Mr. GRIFFITH: I think after Mr. Burt's statement that even our very able business friend Mr. Newton may be satisfied with the character of the security. As a shareholder I was rather struck that while our late debentures were merely a temporary obligation, this new stock will be permanent. That is the interpretation that I put on Mr. Burt's statement.

The SOLICITOR: Certainly.

Mr. GRIFFITH: And that we have not the power of paying it off?

The SOLICITOR: Yes, you can buy up this stock, but not call it in.

Mr. GRIFFITH: That is the same thing under a different name; but certainly it is an advantage to the new debenture holders that they should have a direct charge on the Company—that it should be a mortgage. I only hope that the burden on us will not be a permanent one, and that we shall not have an encumbrance for any length of time. You said that our property is now becoming of a permanent character, permanent in its nature, permanent in its prosperity, permanent in its influence, and I hope sincerely in the good fruit that it will produce. At the commencement of your speech you said it was matter of congratulation that we should receive 5½ per cent. this time. Congratulation is rather a term of degree, and I should have been pleased had we kept up the old dividend. The present distribution may be satisfactory, but the old one would have been still more satisfactory. Our capital is increasing largely. We have a large income from the African Company, and also from the Black Sea Company, and when our traffic is increasing to such an extent it does seem right that the holders of the property should receive an increased instead of a diminished return. At the same time I am aware that we are all creatures of circumstances. This Berlin Conference that you spoke of may be a most potent power in the management of the telegraphs; but I was sorry to hear the expression you used, that you were "forced" to come into the terms which were imposed by this Conference. The word "forced" is somewhat abnormal. It may be that they used some undue influence with you, or that they possessed some power by which they could use influence with you in regard to the cables. The shareholders consider it would be their duty to support the Directors in opposing any improper force which tends to decrease the income, and therefore their dividends. This new cable to which you have alluded may be one of the most statesman-

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like operations that could be conceived; but I do not think we should give in to the outside public, and that while we increase the facilities for business ws should lower the profit we are entitled to receive. If our property is so permanent in its character, power, and influence, it does seem proper that our shareholders should share in its increased prosperity, and that the increased profits should not be as a rule surrendered to others unless overwhelming force compels it.

Mr. HUSBAND: Before you answer I want to ask you a question with respect to the new line that is to bs laid to Gibraltar. I was going to ask first of all with what money the line is to be laid, whether it is to be laid out of the reserve fund, and I also wish to ask how much it will cost? In relation to the remarks made by the gentleman who has just sat down, in comparing the dividend of 5½ per cent. with 6 per cent. that we had once, one reason why it seems to me reasonable to expect that we should at least keep up the dividend is the fact that we have so large a reserve fund. I see that we have in money £564,000 of reserve capital; but in addition to that I find by our accounts—this is on page 6 of the report—there is a duplicate cable in the Red Sea and Indian Ocean representing £100,000, there is a triplicate Red Sea and other cables representing £300,000, and these, so far as I can see, are made out of the £448,000, which is itself reserve fund, and which is therefore costing no interest, either as debenture or as dividend. It seems, assisted as you are by a million of money and the money's worth in your reserve fund, that to keep up the dividend at 6 per cent. would not entitle the Directors to the credit of having done anything superlatively meritorious. I have no doubt that you will answer my first question, at any rate, as to what is to pay for the new line to Gibraltar, and also what the amount is that it is to cost; and perhaps you would also go the length of saying what dividend you expect that line to make when it is laid.

Mr. FOWLER: There is one question I should like to ask arising out of a remark made as to the issue of their capital. I understood you to say the capital would not be materially increased, which means that it will be increased. I would venture to ask whether that additional capital will be offered in the first instance to the existing shareholders *pro rata* according to their holdings. I presume the capital will be partly ordinary and partly preference, as the Directors may think convenient. I only wish to know if the existing shareholders will be offered their proportion of the capital first.

Mr. BAINES: I was going to ask a question—it is perhaps important to the Company's interests—whether in the event of your negotiations with the French Government as to renewing your concession with them failing—whether any loss of time will be made in transmitting messages by the altered route?

The CHAIRMAN: First I have to thank Mr. Newton for bringing the question of the security of our new debentures before the shareholders, and I think he will be pleased with the reply of our solicitor. You are getting better security for your 4 per cent. than you had for your 5 per cent. In regard to Mr. Griffith's remarks, it is always very pleasant to keep up the full extent of your dividend, but you must remember when we established the bonus principle I stated to the shareholders that we would consider the 5 per cent. as our dividend, and that when we could pay bonuses we would do so—that the bonus was not to be looked upon as a permanent thing, but that it should be of a fluctuating character, and be 1 per cent. for the year, or 2 per cent., or ½ per cent., according to circumstances. I merely mention that to show you that the bonus is distinct from the dividend. The reason that we did not pay ½ per cent. for the first half year was that at Berlin an alteration took place in the land line systems by which the European Governments, with their long purses behind them, came to an arrangement which obliged us to alter our tariff. We were forced, therefore, to reduce our rates, and that amounted to £40,000 a year. That wiped away for the time our bonus, and now, with time going on, we are to a certain extent recouping our lost traffic. I hope next half-year we may again pay our ½ per cent., and therefore take up the position of paying our bonus, but still as distinct from paying our dividend. There will be great fluctuations in telegraph property. There must be. It is an uncertain property, I say, still; but at the same time we know in our shallow water where we can pick up a cable, and we are doing it every day. Demands, however, may come upon us at any time, and we must keep ahead of the wants of the Government and of the country, and in keeping ahead of these wants we have received great and important consideration from the Government. For instance, we had the exclusive right for a very considerable number of years of landing cables in Egypt. That is an advantage to this Company which is worth almost untold money, particularly when you look to the fact of the competition in connection with the Atlantic cables at the present moment, for those companies are paying practically no dividend at all. It has been our object so to make our arrangements as to regulate our traffic, and maintain a respectable dividend, and a permanent dividend, and that we have done up to the present time. I would say to Mr. Griffith that we cannot stand still. That would be impossible. If we were to stand still we must go back. There is an increasing demand one way or another, and we must, as far as possible, meet that demand, and be ahead of it. Replying to Mr. Husband, the Chairman explained how the Company proposed to pay for the new cable without materially increasing the capital account. I am looking forward to a very large increase in the traffic. I think it must come, looking to the arrangements likely to be made with Australia for lower rates. Therefore, with our new cable down we are quite independent of France. Still, if France is reasonable—they do not show a very good disposition to meet us up to this moment—yet if next year, when our concession expires with the French Government, they say that we shall hold the cable, it will be an advantage, looking forward to this expected increase of traffic. This will give us an alternative line. I think these remarks will satisfy you that we are reducing the expenses of the new cable to a minimum. We are going to pay towards that cable what we pay to the French Government and other companies at the present moment, and I hope that that will be satisfactory to you. Mr. Fowler asked if we are prepared to give the shareholders *pro rata* the option to subscribe to the capital we shall require for the new cable. I assure you we are going to finance that so as practically to add nothing to the capital. I am as far as possible against adding to the capital, but I think you should be more satisfied with a permanent 5 per cent. and an occasional bonus now and then than leaving our system to drift and competition to arise, and permitting your dividends to be reduced to a mere nominal amount. It is our business to do our work so well that neither Governments nor the outside public will try to tread upon our ground. I was asked if there would be any delay in transmitting the messages. Our arrangement with France goes up to next year; but France may be in a blaze to-morrow for what I know. Judging from what we read in *The Times* the state of things looks very alarming. At all events, to show you how much alive we are to the position—though we do not talk about it, as we do not want to add to scares—the ship is now at Porthcurnow with a large amount of cable on board, and, I believe, could lay the cable in a month.

Mr. NEWTON: Will you compete with your new cable with the Direct Spanish? We are all one company.

The CHAIRMAN: We do not lose sight of that. We are even anxious now to come to an arrangement with Spain. Our negotiations, indeed, are so far advanced that we shall have one of these days an alternative line from Bilbao to Barcelona connected with our system, and from Barcelona we shall connect with our main system at Gibraltar at very small expense. That would give us another line. "Sufficient for the day," however. We have it all in view, and are losing sight of nothing, our desire being to place our Company, in the event of war, in such a position that it will be able to meet, not only public requirements but Government requirements as well. The resolution has been moved and seconded, and with these few remarks I now put it. Those in favour of the motion hold up their hands. To the contrary. Carried unanimously. That closes the meeting.

Major LESLIE: Will you let me move a vote of thanks to our Chairman? I think we must be all very much pleased and gratified at hearing such an eloquent and pleasing statement on our position, and the success we have achieved in attaining to such a fair dividend. After the loss that was caused to us through the action of the Powers of Europe, I think what has been done for us deserves our best thanks.

Mr. GRIFFITH: I shall be happy to second the motion. I am sure that the shareholders will support the Directors whenever any improper action is brought against us by the Governments, with their long purses. We are indebted to Mr. Pender for the kind way in which he has answered our questions. We are indebted to him also for the great experience and skill which he has displayed in the management of the Company, and I certainly cordially support the proposal that we tender a vote of thanks to Mr. Pender and his colleagues.

Major LESLIE put the motion, and it was carried unanimously.

The CHAIRMAN: Gentlemen, it is the greatest possible pleasure to my colleagues and myself to have an expression of the renewed confidence of the shareholders. You may rest assured that the experience we have gathered over many years, as well as the position we have attained, has arisen in a great measure from the confidence which the shareholders have shown in us from time to time at these half-yearly meetings. We have had to-day one of our most severe critics with us. We have a great deal more experience here to-day than we had a few years ago. We have been always glad to have hints given to us, and we have never lost sight of them, and where we have thought they were right and proper we have taken advantage of them. The result is that the position which this Company occupies to-day is second to that of no other telegraph system in the world, and it will continue to receive our most careful attention. We find those who came at first to be severe on us now come to compliment us. That is our reward. We are much obliged to you for your attendance here to-day.

The proceedings then terminated.

The Telegraph Construction and Maintenance Company (Limited).

The half-yearly general meeting of this Company was held on Tuesday, at the offices, 38, Old Broad-street, E.C., Sir George Elliot, M.P., in the chair.

Mr. WILLIAM SHUTER (the Manager) having read the notice convening the meeting,

The CHAIRMAN said: At the request of my colleagues I occupy the chair owing to the absence of our worthy and highly esteemed chairman, Sir Daniel Gooch, who has had a slight accident. I am very thankful and glad to say that I believe it is only slight, but sufficient, I believe, to confine him for a few days. We should all very deeply regret the loss of the useful attention of so valuable a colleague as our Chairman. Well, now, as to the business before the meeting, this is really practically so insignificant that were it not for the purpose of the shareholders keeping touch as it were with what is going on from time to time these half-yearly meetings, which were instituted some years ago, might be dispensed with. At the same time we are very glad to see all of you here, and I will just point out that which will appear to be the only business with which we have to make you acquainted. It is the work done for the half year under contract. We have connected the Italian ports in the Red Sea with Aden, using 359 miles of cable—that is one thing done. The next thing is we have repaired the German Union Company's cable in the North Sea. With regard to the more important work which we are now engaged upon, the "Scotia," which is one of our excellent ships, the property of the Company (we have not to charter vessels now) left England on the 11th inst. with 1,300 miles of cable on board to con-

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nect the Land's End with Lisbon and Gibraltar, and she is now carrying out that work. Submarine telegraph companies find it almost necessary to duplicate their lines, and wherever there is one cable another in course of time is required. That is very much what constitutes the life, as it were, of this Telegraph Construction Company, to go on developing and replacing, and I hope it will continue so for many years. I do not know that I have more to report to you than merely mention these facts. We are hopeful that we shall continue to satisfy the shareholders; at the same time we have a very great staff, and we are desirous to be employed, and we are not without prospect that that may be continued to us. I believe there is no resolution to submit; it is merely that we come to see you, and so long as we can go on paying our dividends I am sure we will always be quite certain to have your confidence, and that is what the business is, not to have too much curiosity or prying into what is being done, but to be satisfied with a good dividend.

A SHAREHOLDER: I am sure I am only expressing the regret of all the shareholders at the intelligence we have from you (and which we knew for ourselves) as to the accident which has befallen the worthy Chairman. You may recollect at the last half-yearly meeting I asked some questions of the Chairman with regard to the electric light, and the Chairman very properly, if I may say so, declined to say anything on the ground that an action was then pending, and which was shortly to be brought to a conclusion. That action has now come to an end favourably to this Company, I believe, and I think the shareholders would be glad to know, Sir, from you, if you can tell them, in the absence of the Chairman, whether you propose to take any steps in developing the electric light through the medium of this Company?

The CHAIRMAN: The hon. shareholder has asked a question which I think is very pertinent; the litigation has been successful. It was resisted by the Great Western Railway; it is not our litigation, we were not subject to its costs, and it has been terminated favourably. We have before us there, what was contemplated, a great example of what can be done, and I believe it is the subject of serious consideration with the Directors what use and how far the experiment may be utilised in connection with the development of the business of this Company. I hope that answer will be satisfactory to everyone. We hope it may become useful, and that we may be able to do any work in connection with electricity, so far as we are concerned with the materials we have, that may be required. I do not know that there is anything more.

Mr. WILLIAM SHUTER: If you will allow me I will read this notice relative to the Second Bonus Trust:—"The Second Bonus Trust (which formed part of the dividend paid to shareholders on the Company's register in February, 1885), the trustees having realised the balance of shares constituting the trust, the above certificates, with Coupon No. 24 attached, are now being paid off at the rate of £1. 7s. per £5 nominal value (£2. 10s. being paid off in August, 1881). Capital unclaimed at Messrs. Barclay's Bank:—First distribution about £1,000, Second and Final £11,000, Coupons £500." That will go forward in the report, and I hope the claims will come forward.

A vote of thanks to the Chairman and Directors then terminated the proceedings.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

A meeting of the shareholders in this Company was held on Tuesday, at the Cannon-street Hotel, Mr. S. W. Silver presiding.

The SECRETARY (Mr. W. J. Tyler) having read the notice convening the meeting,

The CHAIRMAN said: The shareholders will be aware that the books of the Company are not made up until the close of the year. They will not be surprised to hear from me that the same keen competition that has already been alluded to is still met with by the Company as a trading concern, and I need scarcely remind you that that state of things requires on the part of the managers and others the greatest possible attention to effect sales, which I hope, when the books are made up, will be found to justify the motion which I now beg to propose, namely, "That an interim dividend of 5 per cent., or 10s. a share, free of income-tax, be payable on and after the 20th inst."

Mr. NEIL BANNATYNE seconded the motion, which was carried unanimously, and a vote of thanks to the Chairman and Directors having been cordially passed, the proceedings terminated.

Anglo-American Telegraph Company (Limited).

Report of the Directors to be presented to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, 27th inst., at half-past one o'clock:—

The total receipts from the 1st January to the 30th June, 1887, are estimated at £100,534. 9s. 3d. This amount, however, is subject to revision, dependent upon the result of the law-suit now pending between this Company (on behalf of the associated Atlantic cable companies) and the Paris and New York Telegraph Company. The traffic receipts show a decrease as compared with the corresponding period of last year of £16,492 consequent upon competition, a reduced tariff, and the fact that from 1st January to 4th May, 1886, the 1s. 8d. rate was in force. The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £47,211. 2s. 7d. One quarterly interim dividend of 5s. per cent. on the ordinary stock, and of 10s. per cent. on the preferred stock, was paid on the 1st May, 1887, absorbing £17,500, and second quarterly dividends of similar amounts will be distributed on the 30th July, 1887, leaving an estimated balance of £18,323. 6s. 8d. to be carried forward to the next account. The Company's repairing ss. "Minia" has been engaged during the past half-year in the repair of the 1873 cable off Valentia, Ireland, and the St. Pierre Duxbury cable off Seal Island, Nova Scotia. She has also executed three repairs for the Direct U.S. Cable Company and two for the Western Union Telegraph Company, the remuneration for which will be found in the revenue account. The Company's system of cables and land wires is in good working order, with the exception of the Brest St. Pierre and St. Pierre Duxbury cables, the former of which was broken in deep water at a distance of 600 miles from Saint Pierre on the 9th November, 1886, and the latter in shallow water at a distance of 380 miles from Duxbury on the 15th June, 1887. The Company's ss. "Minia" left London on the 14th inst. with 300 miles of deep sea cable on board, to effect the necessary repairs. The notice given by the Paris and New York Telegraph Company on the 31st December, 1886, to determine thenceforth, so far as that company was concerned, the joint purse agreements of the 24th September, 1880, and the 12th May, 1882, was submitted to eminent counsel in Paris, and, upon their advice, the associated cable companies resolved that an action should be brought by the Anglo-American Telegraph Company against the Paris and New York Telegraph Company before the Paris Tribunal of Commerce to enforce specific performance of the agreements under heavy penalties. This action is now proceeding, but as the accumulation of business before the Tribunal of Commerce is very great, it is feared that the hearing will not take place for some time. The tariff of 6d. per word has been in operation during the whole of the past half year, and has resulted in a still further increase of traffic carried by the associated companies. In consequence, however, of the Paris and New York Telegraph Company not having rendered their accounts for the period now under review, it is difficult to give a reliable estimate of the entire increase which has taken place; but inasmuch as the three companies which still work under the joint purse agreements have carried a much larger traffic than they did in the half year ending the 31st December, 1886, it is fair to assume that the total number of words carried at the sixpenny rate must have been largely augmented.

The Direct United States Cable Company (Limited).

Report of the Directors for the six months ended 30th June, to be presented at the twentieth ordinary general meeting of the Company, to be held at Winchester House, 50, Old Broad-street, E.C., on Friday, the 29th inst., at 2 p.m.:—

The half-year's revenue (which is subject to adjustment on settlement of the pending proceedings against the French Company), after deducting out-payments, amounted to £23,571. 15s. 4d., against £28,445. 0s. 9d.) (after similar deductions) for the corresponding period of 1886, being a difference of £4,873. 5s. 5d., against the half year under review, notwithstanding a large increase in the volume of traffic carried at the 6d. rate. This difference is entirely owing to the higher tariff in force during the first four months of 1886. The working and other expenses for the same period, including income-tax, but exclusive of cost of repairs of cables, amounted to £15,905. 3s. 2d., leaving a balance of £7,666. 12s 2d. as the net profit of the half year, making with £228. 18s. 8d. brought forward from the previous half year, and £4,246. 9s. 2d. transferred from the reserve fund account a total of £12,142. For the corresponding half year of 1886 the working expenses and other payments amounted to £15,866. 19s. 7d. Three quarterly interim dividends of 2s. each per share amounting to £18,213 have been declared and paid during the financial year, and a final dividend of 2s. per share is now proposed, making, with the three interim dividends 2 per cent. for the year, being a total distribution of £21,284. The interest on the reserve fund will be utilised to provide for this final dividend. A break occurred in the short section of cable on the 4th Feb. last, and was repaired on the 10th of March. On 3rd April the main section of cable was interrupted, and was repaired on 10th of same month. A further break in the short section took place on 13th April, and was repaired on 22nd April. The cost of repairing these three interruptions, including spare cable used, amounted to £5,223. 7s. 3d., which has been charged against the reserve fund as usual. The sixpenny tariff is still in force, and the volume of traffic shows a large increase.

Pursuant to the provisions of the Articles of Association, two of the Directors, viz., John Pender, Esq., and E. M. Underdown, Esq., Q.C., retire by rotation, and being eligible, offer themselves for re-election. Mr. John G. Griffiths and Mr. John Sawyer, the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the half year ended 30th June, 1887, to be presented at the thirty-second ordinary general meeting of shareholders, to be held at the offices of the Company, 61, Old Broad-street, E.C., on the 27th July, 1887, at 1 o'clock:—

From the report it will be seen that the gross receipts (including the balance brought from last account) amount to £21,292. 19s. 6d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £6,552. 8s. 11d., leaving a sum of £14,740. 10s. 7d. to the credit of revenue account. Of this the sum of £4,500 has been added to the reserve fund, increasing that fund to £71,000. The dividend on the preference shares will absorb £3,000, and leave £7,240. 10s. 7d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, the balance, £240. 10s. 7d., being carried forward to the current half year's account. One of the harbour lengths at Cienfuegos having become worn out, a new length has been laid by Mr. Keith, the Company's engineer, to take its place. The main cables have continued throughout the half year, and are at present, in good working order. The Director who retires from the Board at this time is Mr. Joaquin de Mancha, who, being

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eligible, offers himself for re-election. Mr. Thomas Greenwood, the auditor, also retires, and offers himself for re-election.

Submarine Telegraph Company.

Report of the Directors to be submitted at the meeting of the proprietors of this Company, to be held at the offices of the Company, 2, Throgmorton-avenue, London Wall, E.C., on Monday, the 25th inst., at one o'clock p.m. :—

The accounts for the six months ending 30th June, 1887, show a result which enables the Directors to add the usual proportion of the receipts to the reserve fund, and to recommend a dividend at the rate of 12 per cent. per annum, and to carry over a balance of £979. 5s. 1d. to the next account. The dividend for the corresponding period of 1886 was at the rate of 12 per cent. per annum also, and the balance carried over was £523. 5s. 7d. The average length of the messages transmitted in the half year has been 11·06 words, against 11·05 in the corresponding six months of 1886, but there has been an increase of 135,427 messages in 1887 compared with 1886. The total working expenses for the half year of 1887 show an increase of £1,005. 13s. This increase is accounted for chiefly under the heads of "Salaries and Wages," "Repair to Premises," and "Repairs and Insurance of Steamer." The number of accidents to the cables in the two half years has been about the same. All the Company's cables, as well as those worked by the Company, are in good working order. In their last report the Directors stated that the Right Hon. Robert Bourke (now Lord Connemara) had accepted the important office of Governor of the Presidency of Madras, and had in consequence resigned his seat on the Board of Directors of this Company. The Hon. John Stewart Gathorne-Hardy, M.P., had been appointed by the Board to fill the vacancy caused by Lord Connemara's resignation, subject to the approval of the proprietors. The Board recommend the election of Mr. Gathorne-Hardy as a Director of the Company.

Globe Telegraph and Trust Company (Limited).

Report of the Directors to be presented to the shareholders at the fourteenth ordinary general meeting of the Company to be held at Winchester House, 50, Old Broad-street, E.C., on Thursday, the 28th July, at 2 o'clock :—

The net revenue of the Company for the year, after deduction of expenses, amounts to £146,344. 17s. 2d., which, with the balance of £1,564. 6s. 2d. brought forward, makes a total of £147,919. 3s. 4d. From this amount there has been distributed the sum of £100,246. 10s. 11d. in interim dividends, leaving an available balance of £47,662. 12s. 5d. The Directors recommend payment of a final dividend for the year of 3s. per share on the preference shares, and of 2s. 3d. per share on the ordinary shares, making, with the former distributions, a total dividend for the year of 6 per cent. less income-tax upon the preference and 2¾ per cent. net upon the ordinary shares, carrying forward a balance of £1,439 9s. 11d. The reduction of the dividend on the ordinary shares is attributable to the continuance during the current year of the sixpenny traffic rate by the Atlantic Companies, in which this Company holds stocks and shares. Sixty of the shares of the German Norwegian Cable Company have been drawn and paid off at par, and the proceeds have been carried to credit of the capital account. The Company has acquired 400 additional shares in the French Telegraph Company, Paris to New York. By order of the High Court of Justice the preference capital of the Direct Spanish Telegraph Company was reduced from £10 per preference share to £5. In all other respects the Company's investments remain the same as in last year's accounts. In conformity with the Articles of Association, Mr. William Ford and Sir Daniel Gooch, Bart., two of the Directors, retire, but, being eligible, offer themselves for re-election. The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and Mr. William Griffith, B.A., Barrister-at-Law, also retire at the meeting, and offer themselves for re election.

CITY NOTES, &c.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION (LIMITED). The Anglo-American Brush Corporation has issued the following circular to their shareholders :—

Sir,—I am instructed by the directors to inform you that of the 5,000 new shares recently offered for subscription in pursuance of the resolution passed at the last general meeting of the shareholders only 1,354 shares have as yet been taken up. The additional capital thus provided is not sufficient to meet the requirements of the corporation as a result of the acquisition of important undertakings in Austria-Hungary, and of other investments made for the purposes of further developing its business and maintaining and strengthening its position. Having regard also to the fact, already known to the shareholders, that the increasing business of the corporation has for some time past been conducted under disadvantages consequent upon inadequate working capital, the directors have decided that in the best and permanent interests of the proprietary it is desirable to make a call of £1 per share on the shares upon which only £3 per share have been paid. This call will enable the corporation to satisfactorily complete the arrangements already sanctioned by the shareholders for the necessary extension of its manufacturing and other operations, and by placing the finances on a more favourable footing facilitate the carrying out of important contracts. The directors have pleasure in stating that, considering the present depressed state of the electric light industry, the business of the corporation continues to improve in volume, though in face of keen competition and consequent fall of profits it is necessary whilst practising the most rigid economy to secure all the advantages which a command of adequate working capital affords.—I am, Sir, your obedient servant,

E. GARCKE, Secretary.

112, Belvedere-road, Lambeth, London, S.E., 16th July, 1887.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 15th July are £2,331, as compared with £2,741 in the corresponding period of 1886. The March receipts, estimated at £6,599, realised £6,708.

WOODSIDE ELECTRIC WORKS.—Mr. Joseph Davenport Finney Andrews has ceased to have any connection with the Woodside Electric Works, South Woodside-road, Glasgow, which are now under the charge of Mr. Rankin Kennedy.

NEW COMPANIES REGISTERED.

CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—Registered by H. Philpots, solicitor, 25, Bedford-row, W.C., with a capital of £10,000, in shares of £5 each. Object, to carry on the business of an electric lighting, motive power and supply and telephone company in all its branches. The directors shall not be more than twelve nor less than three in number, and the first shall be Mr. Henry Jasper, High-street, Chatham ; Mr. William James Mackey, High-street, New Brompton, and Mr. Charles Thomas Smith, High-street, Chatham. The general manager is Mr. Mark Parker. Qualification, the holding by each of at least 20 shares in the company. Remuneration to be determined in general meeting. The temporary registered offices of the company are at 22, High-street, Chatham.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. July 20.		Business Done Week Ending July 20. Highest.		Lowest.	
Anglo-American	37,	38	37½		36½	
Do. Preferred	60,	61	61		59½	
Do. Deferred	14½,	15½	15½		14½	
Brazilian Submarine	11,	11¼	11¼		11 1-16	
Cuba	12,	12½	12½		—	
Do. Preference	18,	19	—		—	
Direct Spanish	2¾,	3	—		—	
Do. Preference	7½,	8½	—		—	
Direct United States Cable	9,	9½	—		—	
Eastern Telegraph	11,	11¼	11¼		10⅞	
Do. 6 per Cent. Preference	14,	14½	14 7-16		14	
Do. 5 per Cent. Debentures, 1899	107,	110	—		—	
Eastern Extension	11½,	11⅞	11⅞		11⅝ xd	
German Union	10½,	11	10⅞		—	
Globe Telegraph and Trust	5¾,	5⅞	5 9-16		5 7-16	
Do. Preference	13,	13½	13½		13	
Great Northern	13½,	14	—		—	
Indo-European	34,	36	35½		35	
Reuter's	7½,	7¾	—		—	
Submarine	180,	190	183		180	
West India and Panama	⅝,	¾	—		—	
Do. 1st Preference	8½,	9	8¾		—	
Western Brazilian	8,	8½	8 3-16		8	
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	104,	107	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	—		—	
Oriental	½,	⅝	—		—	
United Telephone	12,	12½	12⅜		12¼ xd	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	2⅛		—	
Do. (fully paid)	3,	4	—		—	
Swan	1½,	1½	1⅝		—	
Maxim Weston	3-16,	5-16	—		—	

MISCELLANEOUS.

Telegraph Construction	35½,	36½	37		36¼ xd	
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23⅜		23	

THE ELECTRIC APPARATUS COMPANY, Limited.

Head Office and Warehouse: 50, Bow Lane, Cheapside, E.C.
Depots: 4, Charing Cross, S.W., and 65, Faulkner St., Manchester.
Works: Arnold Road, Bow, E.

Electric Light Fittings, Edison-Swan Lamps, Schuckert's Ammeters, Voltmeters and Speedometers.

Specially Low Quotations for Electric Light Cables.

BELLS, INDICATORS, BATTERIES, WIRES, &c.
MEDICAL APPLIANCES.
SHIPPERS AND THE TRADE SPECIALLY STUDIED.
NO CONNECTION whatever with any Firm trading under a SIMILAR TITLE

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NOTES.

BURTON-ON-TRENT.—A telephone exchange has been opened in this town by the National Telephone Company.

PORTADOWN.—We understand that the commissioners of Portadown are making inquiries about electric lighting.

A NEW WEST INDIAN CABLE.—The Spanish Government has authorised the construction of a cable between the islands of Cuba and Hayti.

"THE TELEGRAPH OF THE FUTURE."—This is the title of a work which is announced by Messrs. Trübner to appear shortly. We understand, however, that it deals with "psychic force."

SHIP LIGHTING.—The steamer "City of Aberdeen," belonging to the Aberdeen Steam Navigation Company, is being fitted with electric lighting plant by the Anglo-American Brush Company.

BRUSSELS.—Several large electric installations are now being arranged in Brussels. Amongst the most important are the lighting of the new Military Hospital, the Shaerbeck Railway Station, and at Meiselberke Station.

MARENNES.—Electric lighting continues to make steady progress amongst the towns and villages in the south-east of France, where water power is happily available. The little town of Marennes and the village of Vierza will shortly be added to the list. The contractor is M. Grejbel.

A NEW LUBRICANT FOR COMMUTATORS.—M. Bandsept informs us that he has found that Marseilles soap makes an admirable lubricant for the commutators of dynamo machines. It should be applied in very small quantity, and will be found highly efficacious in preventing the wear of the brushes.

THE TELEPHONE SUITS IN THE STATES.—According to a telegram in the *Standard* judgment has been delivered in favour of the Bell Telephone Company in its suit against the Globe Company, who were making use of Bassano and Slater's instruments. The defence was based upon the supposed priority of Meucci, the Italian inventor.

TRANS-OCEANIC TELEPHONY.—The New York daily papers want to know why their electricians do not lay a telephone cable to Europe. Mr. Barnum, we learn, "is considering the project," and thinks of ordering a special cable to transmit opera from Paris. We venture to recommend Mr. Barnum to study the writings of Oliver Heaviside.

BANK LIGHTING.—The Union Bank of London, who have for a long time past been considering the question of the electric lighting of their new premises in Princes-street, have now placed the work with Messrs. B. Verity and Sons, of King-street, Covent Garden, under the supervision of Messrs. Drake and Gorham, who are acting as engineers for the bank.

PERSONAL.—We understand that Major-General Webber, C.B., has resigned the position of managing director of the Anglo-American Brush Electric Light Corporation, and has accepted the appointment of consulting technical adviser. Mr. Emile Garcke, who for upwards of four years has been the secretary of the corporation, has been appointed manager and secretary.

A NEW INSULATING PLATE.—An insulating plate which, while very thin and light, is absolutely impermeable to moisture and to air, may be made by taking two leaves of tin-foil coated with a thin layer of gutta percha solution (dissolved in benzine or carbon di-sulphide) and placing them face to face, separated by a leaf of thin paper of close texture. This suggestion is due to M. Bandsept.

FRANCE AND OCEAN CABLES.—The scheme for promoting a cable company under the patronage of the French Government to connect the French Colonies in South America with the mother country, referred to at considerable length in our issue of February 18th, pp. 328, 334, has met with another rebuff. The Chamber of Deputies has postponed *sine die*, by a majority of 237 to 208, the first reading of a Bill to form this company.

THE PROPOSED ELECTRIC TRAMWAY AT BRAY.—The opposition to the proposed electric tramway from the terminus of the Dublin, Wicklow, and Wexford Railway Company to the strand at Bray Head having been withdrawn, the scheme has now received the sanction of the Judicial Committee of the Privy Council, and only awaits the approval of the Lord Lieutenant. We understand that the work will be placed in the hands of Messrs. Woodhouse and Rawson.

THE CARBON TRADE IN AMERICA.—We recently mentioned that the makers of electric light carbons in America had formed a combination to raise the price of carbons to remunerative rates. This move has, however, been met by the electric lighting companies of New York, who have issued a circular proposing the formation of a committee representing the whole of the arc lighting companies to consider the advisability of undertaking the manufacture of their own carbons upon a mutual basis.

SWANSEA.—The Western Counties and South Wales Telephone Company have now extended the Bristol-Cardiff trunk line as far as Swansea, a total length of 116½ miles. The line will shortly be carried on to Llanelly, 12 miles further. At present only a single wire has been completed between Swansea and Cardiff, and that portion of the line is worked through an earth return. In another fortnight, however, it is anticipated that the metallic circuit will be complete throughout. In the meantime conversation between Bristol and Swansea is even now carried on without difficulty.

THE TAMINE ACCUMULATOR.—M. Tamine, of Brussels, has devised an accumulator of the Planté type, in which the liquid consists of a saturated solution of sulphate of zinc, to which is added 50 per cent. of sulphuric acid, 5 per cent. of sulphate of ammonia and 5 per cent. of sulphate of mercury. In making up the cell it is stated that the ingredients should be poured in in the reverse order to that here enumerated. The E.M.F. of the cell is given as 2·3 volts. The addition of sulphates of mercury and ammonia is said to prevent the formation of sulphate of lead on open circuit. The solution appears to be practically identical with that employed in M. Mezerolle's cell.

MALTON.—The Malton proposals have resulted pretty much in the way which might have been anticipated after reading the details which we gave in our last issue; that is to say, out of twenty-four firms who examined the specification of the borough surveyor not a single one proceeded to tender. This result is far more satisfactory than the recurrence of any catch-penny offers such as have too often been made. The Gas Company offered to provide the stipulated number of burners, to consume 5ft. of gas per hour, and to burn 1,700 hours per annum, at a yearly rate of £2. 3s. 6d. per lamp. This offer led to a heated discussion, and the matter still remains unsettled.

PARIS.—It is reported that the Edison Company has applied for powers to open a central lighting station in the neighbourhood of the Théâtre Français. MM. Davy Lepage and Cie. are also negotiating for the establishment of a station in the Boulevard de Strasbourg.—The Paris General Telephone Co. has contracted for supplying the Buenos Ayres Telephone Co.,

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just formed, with all the requisite instruments, material, and plant for the establishment of the telephone system in the Argentine capital. The Paris Company has also received an order for cables from the Buenos Ayres Municipality, the latter having decided to make an experiment in lighting the city by electricity.

WHAT IS A "SELF-REGULATING" DYNAMO?—A correspondent is anxious to be informed "whether a patent compound-wound self-regulating dynamo-electric machine, in which the brushes are shifted by hand for variable loads, and an adjustable resistance is placed in circuit with the shunt coils, may be considered to possess any marked superiority over machines in which these features are absent?" After carefully considering this curious point raised by our correspondent we are inclined to reply to his question in the negative. But as we are aware that other views are held by (presumably) high authorities, we cannot ask him to attach too much importance to an editorial opinion.

MEETING OF THE INSTITUTE OF MECHANICAL ENGINEERS.—The summer meeting of the Institute of Mechanical Engineers will be held in Edinburgh, on Tuesday morning, August 2, and Wednesday morning, August 3, in the University. The chair will be taken at half-past nine o'clock by the President, Mr. Edward H. Carbutt, in the Natural History Lecture Theatre. The following amongst other papers have been offered for reading and discussion:—"A Description of the Electric Light on the Isle of May," by Mr. David A. Stevenson, of Edinburgh; "On Electro-Magnetic Machine Tools," by Mr. Frederick John Rowan, of Glasgow; "On the Position and Prospects of Electricity as Applied to Engineering," by Mr. William Giepel, of Edinburgh.

SECONDARY BATTERIES IN BELGIUM.—We understand that a syndicate has been formed at Brussels with a view to the acquisition of the whole of the Belgian patents (of any practical importance) relating to secondary batteries. It is believed that arrangements will be concluded with most of the present holders on the basis of an average royalty of two centimes per kilogramme of plates manufactured. The principal object in view is to unite all the valuable features at present distributed amongst numerous patents so as to obtain the best possible form of cell free from all patent troubles and trials. This is a sensible idea, and we shall hope to hear that the negotiations have been carried to a successful issue in time for the International Exhibition which is to take place next year at Brussels.

THE BRUCE ELECTRICAL WAR BALLOON.—On Monday evening last Mr. E. S. Bruce exhibited his electric war balloon at the Kensington Town Hall. The apparatus is intended for aerial signalling. The balloon is of varnished cambric, with a capacity of 2,000 cubic feet. The interior contains a frame, in the form of a ladder, suspended in its centre, holding six incandescent lamps of the Edison and Swan type, of 25 volts, the current being conveyed to the frame by a flexible double cable. The lamps are controlled from a switch board, the contacts being of carbon instead of platinum, and the balloon is held captive by a line of Italian hemp capable of bearing a breaking strain of 25 tons. The apparatus is worked with an E.P.S. battery of 25 cells. We understand that the trials which have been made at Chatham have convinced the military authorities of the utility of the idea. The apparatus exhibited has been made for the Belgian Government.

THE PARIS, 1889, EXHIBITION: PROPOSED NOVEL ELECTRIC RAILWAY.—In a paper read by M. Eugène Hénard before the French Society of Architects, it has been proposed to lay down a "continuous" electric railway or "carrying platform" around the whole of the grounds of the Paris Exhibition. The idea is to lay the rails in a trench of such a depth that an ordinary flat-topped railway waggon just reaches the surface of the ground; the whole circle would then be filled with a train of such waggons coupled close together and provided with a continuous floor. This train is to be driven at a walking pace by a number of electric motors placed at intervals upon or underneath the waggons. Passengers can thus step on or off at any point, and no fares would be charged except for seats. The working of the line would be controlled from signal boxes placed at suitable distances, from each of which the train may be stopped at any moment by opening one of the main leads. The idea strikes us as a rather good one, and there should be no difficulty in carrying it out with entire success, and with great convenience to visitors.

SEILER'S HOTEL ANNUNCIATOR SYSTEM.—In order to reduce the number of electro-magnetic drops which are required in fitting a large building with electric bells and annunciators, Mr. P. Seiler (of San Francisco) has brought out a system whose merit consists chiefly in the use of a limited number of annunciators to indicate a much larger number of rooms. This is carried out by placing the numbers of the rooms on fixed tablets arranged in a square or rectangular form, and having two rows of annunciators which run along the top and down one side of the board, so that by the fall of any two of the annunciator drops a particular number is indicated. The arrangement for actuating the drops is ingenious. When a call is first received an annunciator in the horizontal row only is seen to fall. The signal is then acknowledged by the attendant, who presses the key which is found at the bottom of the vertical row of numbers indicated by the drop. The pressing of this key causes the second drop in the vertical row of annunciators to fall, indicating the number of the room, and at the same time giving an acknowledgement of the signal.

METHOD OF PREVENTING THE BLACKENING OF INCANDESCENT LAMPS.—Mr. Ed. P. Thompson has found that the blackening of the glass of incandescent lamps is chiefly due to the carbon particles which are driven off on first closing the circuit when the filament obtains a static charge. In order to avoid this Mr. Thompson has made lamps in which the filament surrounds a loop or stem of copper wire, which passes through the stem of the lamp and is connected to earth; the wire being also provided with several points which project towards the filament. The result is that when the static charge is received the carbon molecules tend to be projected upon the wire, and the blackening of the glass is prevented. Mr. Thompson's theoretical explanation of the effect is certainly sufficiently plausible to merit consideration, but it appears to us that if this view were correct it would follow that incandescent lamps supplied with alternating currents should blacken much more rapidly than with continuous currents, and their life should be much shorter. We have not learnt that such a result has ever been observed, and it would almost appear that this objection is fatal to the static charge theory.

HOW TO FORM A PRIMARY BATTERY COMPANY.—The following instructions upon this interesting and important subject are taken from an American technical journal. The business appears, however, to be tolerably well understood in certain quarters on this side the Atlantic:—"Organise under the laws of the State of Maine; 10,000 shares of stock, par value, $100 per share. Offer to let in your friends on the ground floor at $1 per share. Print some circulars, setting forth the millions [not] made in primary batteries, in times

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gone by; explain indefinitely that a new discovery has been made of an [old] chemical by the aid of which current can be produced for domestic incandescent lighting. There are as gullible investors as ever were caught, and they will bite. Delays are convenient—carbons not ready; cups too porous. Keep this up as long as possible, and then get some batteries, and run one or two incandescent lights far above their candle power. Do not let them burn but a few moments at a time, and a 5 candle-power run up to 25 candle-power will last some days. Comment on the whiteness and steadiness of the light. When people apply for batteries convince them of their folly, and induce them to purchase stock. When the enthusiasm is at its height sell the stock, and be conveniently called to some other section of the world for a year. On returning repeat the same operation."

VULCABESTON.—Vulcabeston is the name of a new material which professes to combine all the valuable qualities of asbestos and india rubber. It is described as forming a substance of the toughness of horn, although it can be made of any degree of flexibility. It is a non-conductor of electricity, and stands the severest test of acids, steam, gases, &c. One of the most important uses of the new material is as a moulded piston rod packing ring, made to fit any sized rod or stuffing box, and to be sprung in place with a slight pressure, one or more rings being used as desired, and forming a perfectly tight steam joint. These rings do not wear the rod, and they are self-lubricating. The first set made of these rings has been in use over eleven months, in a Hartfort, Conn., manufactory, on an engine run at 280 strokes per minute, and is still in perfect order. Vulcanised asbestos piston rod packing in the form of flexible rope, of all sizes, will not shrink or blow out, and is especially adapted for use on locomotives and ocean steamers, and in other places where loss of time in repacking is of the greatest consequence, and where the use of ordinary steam packings would consequently be entirely inadmissible. And it is claimed that in consequence of its great strength and durability it can be used wherever metallic packings have heretofore been necessary. If all this is true the new material may be expected to do good service in connection with engines for central station electric lighting.

GALLANT CONDUCT OF TWO ELECTRICIANS.—We have pleasure in recording two very gallant rescues from drowning which took place last week at Waterford, and of which Messrs. Pope and Bate, of the firm of Laing, Wharton and Down, were the heroes. These gentlemen are at present engaged in the erection of a Thomson-Houston plant for lighting the City of Waterford, and were bathing in the bay on Thursday morning, although the water was somewhat rough. On the left hand side of the bay a strong under-current exists, and after being in the water some time Mr. Bate observed a man in an unconscious condition and drifting out to sea in the current. Shouting to his colleague, they both dashed to the rescue. The drowning man was first reached by Mr. Pope, who, after an exhausting struggle for ten minutes in the heavy seas, brought him safely to land. Mr. Pope found himself completely done up and unable to stand, but while being attended to by Mr. Bate, cries were again heard from the sea, and a priest, Father Dooley, was discovered vainly endeavouring to support another half-drowned individual whom he had gone to rescue. Mr. Bate seized a life-buoy, and again plunging into the water, succeeded, with the aid of a bystander named Phelan, in bringing both men safely to shore. The individual saved by Mr. Pope was a medical student named Keogh, and in the second case Mr. O'Farrel, a ship-broker, was concerned. We are glad to hear from Messrs. Laing, Wharton, and Down that they are taking steps to bring the matter before the Royal Humane Society.

THE PARTNERSHIP BETWEEN GAS AND ELECTRICITY IN AMERICA.—The annual report of the American Electric Manufacturing Company contains the following reference to their alliance with the gas interest:—"The past year has demonstrated the soundness of the opinion long entertained and persistently advanced by the officers of this company, that the gas and electric lighting interests of the country should co-operate instead of antagonising each other. Gas lighting companies have finally come to recognise the fact that their interests are best subserved by the combination of the two illuminants for local lighting purposes under one management, and that it is far better for them to add electric lighting apparatus to their present plants, and thus prepare themselves to meet the entire demand for illumination in their respective localities than to permit others to introduce the newer and more brilliant illuminant as a rival to gas. They have found that such a combination is not only practicable and profitable, but that the adoption of electric lighting by gas companies practically excludes competitors because of the superior economy with which such companies can operate electric lights in connection with their established gas business. Other electric lighting companies have at last perceived that the combination is inevitable, and are tardily endeavouring to obtain the adoption of their respective systems. But the American Company is pretty generally recognised as the pioneer in this direction, and will naturally enjoy the largest share of the patronage of the gas companies, especially in view of the superiority of its apparatus. Recognising the great importance of the company's future dealings with this extensive and important industry, the trustees established a special gas department of the company's business, and have placed in special charge thereof one of the most experienced, successful, and widely known gas engineers in the country."

ELECTRIC TRACTION.—Considerable light is shed upon the causes of the very partial success of electric traction on the Brussels tram lines when we learn that an attempt was made to use a dynamo of old-fashioned type as a motor. Upon the long and steep gradients of the Brussels line the torque upon the armatures must be very great indeed, and it was little short of folly to expect an armature built for a totally different purpose to withstand the strain. Whatever points of divergence have yet to be settled in the theory of dynamos and motors, it is yet fully understood—or at any rate it is high time that it should be—that a motor which is geared in a positive manner, and is liable to be started under a heavy load, must be designed, both mechanically and electrically, on the basis of an output far exceeding its normal rate of working. An old-fashioned dynamo is simply useless for work of this description. The Brussels Company having now fully convinced themselves upon this point, we understand that it has been decided to employ motors of English make, and M. Julien was recently in this country making inquiries. We are pleased to learn that the Julien cells continue to give satisfaction. Each car, weighing with its load of passengers 16,500lb., carries in addition a weight of 3,300lb. of accumulators. This ratio of weight of battery to total weight is slightly lower than that obtained by the Electric Traction Syndicate (as described in another column), but this in part arises from the fact already alluded to, that the motor is too light for its work. But as we are not aware of the total capacity of the cells in the former case, the comparison is not of much value. The battery consists of 120 cells, which are coupled to a switch, so as to

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like operations that could be conceived; but I do not think we should give in to the outside public, and that while we increase the facilities for business ws should lower the profit we are entitled to receive. If our property is so permanent in its character, power, and influence, it does seem proper that our shareholders should share in its increased prosperity, and that the increased profits should not be as a rule surrendered to others unless overwhelming force compels it.

Mr. HUSBAND: Before you answer I want to ask you a question with respect to the new line that is to bs laid to Gibraltar. I was going to ask first of all with what money the line is to be laid, whether it is to be laid out of the reserve fund, and I also wish to ask how much it will cost? In relation to the remarks made by the gentleman who has just sat down, in comparing the dividend of 5½ per cent. with 6 per cent. that we had once, one reason why it seems to me reasonable to expect that we should at least keep up the dividend is the fact that we have so large a reserve fund. I see that we have in money £564,000 of reserve capital; but in addition to that I find by our accounts—this is on page 6 of the report—there is a duplicate cable in the Red Sea and Indian Ocean representing £100,000, there is a triplicate Red Sea and other cables representing £300,000, and these, so far as I can see, are made out of the £448,000, which is itself reserve fund, and which is therefore costing no interest, either as debenture or as dividend. It seems, assisted as you are by a million of money and the money's worth in your reserve fund, that to keep up the dividend at 6 per cent. would not entitle the Directors to the credit of having done anything superlatively meritorious. I have no doubt that you will answer my first question, at any rate, as to what is to pay for the new line to Gibraltar, and also what the amount is that it is to cost; and perhaps you would also go the length of saying what dividend you expect that line to make when it is laid.

Mr. FOWLER: There is one question I should like to ask arising out of a remark made as to the issue of their capital. I understood you to say the capital would not be materially increased, which means that it will be increased. I would venture to ask whether that additional capital will be offered in the first instance to the existing shareholders *pro rata* according to their holdings. I presume the capital will be partly ordinary and partly preference, as the Directors may think convenient. I only wish to know if the existing shareholders will be offered their proportion of the capital first.

Mr. BAINES: I was going to ask a question—it is perhaps important to the Company's interests—whether in the event of your negotiations with the French Government as to renewing your concession with them failing—whether any loss of time will be made in transmitting messages by the altered route?

The CHAIRMAN: First I have to thank Mr. Newton for bringing the question of the security of our new debentures before the shareholders, and I think he will be pleased with the reply of our solicitor. You are getting better security for your 4 per cent. than you had for your 5 per cent. In regard to Mr. Griffith's remarks, it is always very pleasant to keep up the full extent of your dividend, but you must remember when we established the bonus principle I stated to the shareholders that we would consider the 5 per cent. as our dividend, and that when we could pay bonuses we would do so—that the bonus was not to be looked upon as a permanent thing, but that it should be of a fluctuating character, and be 1 per cent. for the year, or 2 per cent., or ½ per cent., according to circumstances. I merely mention that to show you that the bonus is distinct from the dividend. The reason that we did not pay ½ per cent. for the first half year was that at Berlin an alteration took place in the land line systems by which the European Governments, with their long purses behind them, came to an arrangement which obliged us to alter our tariff. We were forced, therefore, to reduce our rates, and that amounted to £40,000 a year. That wiped away for the time our bonus, and now, with time going on, we are to a certain extent recouping our lost traffic. I hope next half-year we may again pay our ½ per cent., and therefore take up the position of paying our bonus, but still as distinct from paying our dividend. There will be great fluctuations in telegraph property. There must be. It is an uncertain property, I say, still; but at the same time we know in our shallow water where we can pick up a cable, and we are doing it every day. Demands, however, may come upon us at any time, and we must keep ahead of the wants of the Government and of the country, and in keeping ahead of these wants we have received great and important consideration from the Government. For instance, we had the exclusive right for a very considerable number of years of landing cables in Egypt. That is an advantage to this Company which is worth almost untold money, particularly when you look to the fact of the competition in connection with the Atlantic cables at the present moment, for those companies are paying practically no dividend at all. It has been our object so to make our arrangements as to regulate our traffic, and maintain a respectable dividend, and a permanent dividend, and that we have done up to the present time. I would say to Mr. Griffith that we cannot stand still. That would be impossible. If we were to stand still we must go back. There is an increasing demand one way or another, and we must, as far as possible, meet that demand, and be ahead of it. Replying to Mr. Husband, the Chairman explained how the Company proposed to pay for the new cable without materially increasing the capital account. I am looking forward to a very large increase in the traffic. I think it must come, looking to the arrangements likely to be made with Australia for lower rates. Therefore, with our new cable down we are quite independent of France. Still, if France is reasonable—they do not show a very good disposition to meet us up to this moment—yet if next year, when our concession expires with the French Government, they say that we shall hold the cable, it will be an advantage, looking forward to this expected increase of traffic. This will give us an alternative line. I think these remarks will satisfy you that we are reducing the expenses of the new cable to a minimum. We are going to pay towards that cable what we pay to the French Government and other companies at the present moment, and I hope that that will be satisfactory to you. Mr. Fowler asked if we are prepared to give the shareholders *pro rata* the option to subscribe to the capital we shall require for the new cable. I assure you we are going to finance that so as practically to add nothing to the capital. I am as far as possible against adding to the capital, but I think you should be more satisfied with a permanent 5 per cent. and an occasional bonus now and then than leaving our system to drift and competition to arise, and permitting your dividends to be reduced to a mere nominal amount. It is our business to do our work so well that neither Governments nor the outside public will try to tread upon our ground. I was asked if there would be any delay in transmitting the messages. Our arrangement with France goes up to next year; but France may be in a blaze to-morrow for what I know. Judging from what we read in *The Times* the state of things looks very alarming. At all events, to show you how much alive we are to the position—though we do not talk about it, as we do not want to add to scares—the ship is now at Porthcurnow with a large amount of cable on board, and, I believe, could lay the cable in a month.

Mr. NEWTON: Will you compete with your new cable with the Direct Spanish? We are all one company.

The CHAIRMAN: We do not lose sight of that. We are even anxious now to come to an arrangement with Spain. Our negotiations, indeed, are so far advanced that we shall have one of these days an alternative line from Bilbao to Barcelona connected with our system, and from Barcelona we shall connect with our main system at Gibraltar at very small expense. That would give us another line. "Sufficient for the day," however. We have it all in view, and are losing sight of nothing, our desire being to place our Company, in the event of war, in such a position that it will be able to meet, not only public requirements but Government requirements as well. The resolution has been moved and seconded, and with these few remarks I now put it. Those in favour of the motion hold up their hands. To the contrary. Carried unanimously. That closes the meeting.

Major LESLIE: Will you let me move a vote of thanks to our Chairman? I think we must be all very much pleased and gratified at hearing such an eloquent and pleasing statement on our position, and the success we have achieved in attaining to such a fair dividend. After the loss that was caused to us through the action of the Powers of Europe, I think what has been done for us deserves our best thanks.

Mr. GRIFFITH: I shall be happy to second the motion. I am sure that the shareholders will support the Directors whenever any improper action is brought against us by the Governments, with their long purses. We are indebted to Mr. Pender for the kind way in which he has answered our questions. We are indebted to him also for the great experience and skill which he has displayed in the management of the Company, and I certainly cordially support the proposal that we tender a vote of thanks to Mr. Pender and his colleagues.

Major LESLIE put the motion, and it was carried unanimously.

The CHAIRMAN: Gentlemen, it is the greatest possible pleasure to my colleagues and myself to have an expression of the renewed confidence of the shareholders. You may rest assured that the experience we have gathered over many years, as well as the position we have attained, has arisen in a great measure from the confidence which the shareholders have shown in us from time to time at these half-yearly meetings. We have had to-day one of our most severe critics with us. We have a great deal more experience here to-day than we had a few years ago. We have been always glad to have hints given to us, and we have never lost sight of them, and where we have thought they were right and proper we have taken advantage of them. The result is that the position which this Company occupies to-day is second to that of no other telegraph system in the world, and it will continue to receive our most careful attention. We find those who came at first to be severe on us now come to compliment us. That is our reward. We are much obliged to you for your attendance here to-day.

The proceedings then terminated.

The Telegraph Construction and Maintenance Company (Limited).

The half-yearly general meeting of this Company was held on Tuesday, at the offices, 38, Old Broad-street, E.C., Sir George Elliot, M.P., in the chair.

Mr. WILLIAM SHUTER (the Manager) having read the notice convening the meeting,

The CHAIRMAN said: At the request of my colleagues I occupy the chair owing to the absence of our worthy and highly esteemed chairman, Sir Daniel Gooch, who has had a slight accident. I am very thankful and glad to say that I believe it is only slight, but sufficient, I believe, to confine him for a few days. We should all very deeply regret the loss of the useful attention of so valuable a colleague as our Chairman. Well, now, as to the business before the meeting, this is really practically so insignificant that were it not for the purpose of the shareholders keeping touch as it were with what is going on from time to time these half-yearly meetings, which were instituted some years ago, might be dispensed with. At the same time we are very glad to see all of you here, and I will just point out that which will appear to be the only business with which we have to make you acquainted. It is the work done for the half year under contract. We have connected the Italian ports in the Red Sea with Aden, using 359 miles of cable—that is one thing done. The next thing is we have repaired the German Union Company's cable in the North Sea. With regard to the more important work which we are now engaged upon, the "Scotia," which is one of our excellent ships, the property of the Company (we have not to charter vessels now) left England on the 11th inst. with 1,300 miles of cable on board to con-

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nect the Land's End with Lisbon and Gibraltar, and she is now carrying out that work. Submarine telegraph companies find it almost necessary to duplicate their lines, and wherever there is one cable another in course of time is required. That is very much what constitutes the life, as it were, of this Telegraph Construction Company, to go on developing and replacing, and I hope it will continue so for many years. I do not know that I have more to report to you than merely mention these facts. We are hopeful that we shall continue to satisfy the shareholders; at the same time we have a very great staff, and we are desirous to be employed, and we are not without prospect that that may be continued to us. I believe there is no resolution to submit; it is merely that we come to see you, and so long as we can go on paying our dividends I am sure we will always be quite certain to have your confidence, and that is what the business is, not to have too much curiosity or prying into what is being done, but to be satisfied with a good dividend.

A SHAREHOLDER: I am sure I am only expressing the regret of all the shareholders at the intelligence we have from you (and which we knew for ourselves) as to the accident which has befallen the worthy Chairman. You may recollect at the last half-yearly meeting I asked some questions of the Chairman with regard to the electric light, and the Chairman very properly, if I may say so, declined to say anything on the ground that an action was then pending, and which was shortly to be brought to a conclusion. That action has now come to an end favourably to this Company, I believe, and I think the shareholders would be glad to know, Sir, from you, if you can tell them, in the absence of the Chairman, whether you propose to take any steps in developing the electric light through the medium of this Company?

The CHAIRMAN: The hon. shareholder has asked a question which I think is very pertinent; the litigation has been successful. It was resisted by the Great Western Railway; it is not our litigation, we were not subject to its costs, and it has been terminated favourably. We have before us there, what was contemplated, a great example of what can be done, and I believe it is the subject of serious consideration with the Directors what use and how far the experiment may be utilised in connection with the development of the business of this Company. I hope that answer will be satisfactory to everyone. We hope it may become useful, and that we may be able to do any work in connection with electricity, so far as we are concerned with the materials we have, that may be required. I do not know that there is anything more.

Mr. WILLIAM SHUTER: If you will allow me I will read this notice relative to the Second Bonus Trust:—"The Second Bonus Trust (which formed part of the dividend paid to shareholders on the Company's register in February, 1885), the trustees having realised the balance of shares constituting the trust, the above certificates, with Coupon No. 24 attached, are now being paid off at the rate of £1. 7s. per £5 nominal value (£2. 10s. being paid off in August, 1881). Capital unclaimed at Messrs. Barclay's Bank:—First distribution about £1,000, Second and Final £11,000, Coupons £500." That will go forward in the report, and I hope the claims will come forward.

A vote of thanks to the Chairman and Directors then terminated the proceedings.

India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

A meeting of the shareholders in this Company was held on Tuesday, at the Cannon-street Hotel, Mr. S. W. Silver presiding.

The SECRETARY (Mr. W. J. Tyler) having read the notice convening the meeting,

The CHAIRMAN said: The shareholders will be aware that the books of the Company are not made up until the close of the year. They will not be surprised to hear from me that the same keen competition that has already been alluded to is still met with by the Company as a trading concern, and I need scarcely remind you that that state of things requires on the part of the managers and others the greatest possible attention to effect sales, which I hope, when the books are made up, will be found to justify the motion which I now beg to propose, namely, "That an interim dividend of 5 per cent., or 10s. a share, free of income-tax, be payable on and after the 20th inst."

Mr. NEIL BANNATYNE seconded the motion, which was carried unanimously, and a vote of thanks to the Chairman and Directors having been cordially passed, the proceedings terminated.

Anglo-American Telegraph Company (Limited).

Report of the Directors to be presented to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, 27th inst., at half-past one o'clock:—

The total receipts from the 1st January to the 30th June, 1887, are estimated at £100,534. 9s. 3d. This amount, however, is subject to revision, dependent upon the result of the law-suit now pending between this Company (on behalf of the associated Atlantic cable companies) and the Paris and New York Telegraph Company. The traffic receipts show a decrease as compared with the corresponding period of last year of £16,492 consequent upon competition, a reduced tariff, and the fact that from 1st January to 4th May, 1886, the 1s. 8d. rate was in force. The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £47,211. 2s. 7d. One quarterly interim dividend of 5s. per cent. on the ordinary stock, and of 10s. per cent. on the preferred stock, was paid on the 1st May, 1887, absorbing £17,500, and second quarterly dividends of similar amounts will be distributed on the 30th July, 1887, leaving an estimated balance of £18,323. 6s. 8d. to be carried forward to the next account.

The Company's repairing ss. "Minia" has been engaged during the past half-year in the repair of the 1873 cable off Valentia, Ireland, and the St. Pierre Duxbury cable off Seal Island, Nova Scotia. She has also executed three repairs for the Direct U.S. Cable Company and two for the Western Union Telegraph Company, the remuneration for which will be found in the revenue account. The Company's system of cables and land wires is in good working order, with the exception of the Brest St. Pierre and St. Pierre Duxbury cables, the former of which was broken in deep water at a distance of 600 miles from Saint Pierre on the 9th November, 1886, and the latter in shallow water at a distance of 380 miles from Duxbury on the 15th June, 1887. The Company's ss. "Minia" left London on the 14th inst. with 300 miles of deep sea cable on board, to effect the necessary repairs. The notice given by the Paris and New York Telegraph Company on the 31st December, 1886, to determine thenceforth, so far as that company was concerned, the joint purse agreements of the 24th September, 1880, and the 12th May, 1882, was submitted to eminent counsel in Paris, and, upon their advice, the associated cable companies resolved that an action should be brought by the Anglo-American Telegraph Company against the Paris and New York Telegraph Company before the Paris Tribunal of Commerce to enforce specific performance of the agreements under heavy penalties. This action is now proceeding, but as the accumulation of business before the Tribunal of Commerce is very great, it is feared that the hearing will not take place for some time. The tariff of 6d. per word has been in operation during the whole of the past half year, and has resulted in a still further increase of traffic carried by the associated companies. In consequence, however, of the Paris and New York Telegraph Company not having rendered their accounts for the period now under review, it is difficult to give a reliable estimate of the entire increase which has taken place; but inasmuch as the three companies which still work under the joint purse agreements have carried a much larger traffic than they did in the half year ending the 31st December, 1886, it is fair to assume that the total number of words carried at the sixpenny rate must have been largely augmented.

The Direct United States Cable Company (Limited).

Report of the Directors for the six months ended 30th June, to be presented at the twentieth ordinary general meeting of the Company, to be held at Winchester House, 50, Old Broad-street, E.C., on Friday, the 29th inst., at 2 p.m.:—

The half-year's revenue (which is subject to adjustment on settlement of the pending proceedings against the French Company), after deducting out-payments, amounted to £23,571. 15s. 4d., against £28,445. 0s. 9d.) (after similar deductions) for the corresponding period of 1886, being a difference of £4,873. 5s. 5d., against the half year under review, notwithstanding a large increase in the volume of traffic carried at the 6d. rate. This difference is entirely owing to the higher tariff in force during the first four months of 1886. The working and other expenses for the same period, including income-tax, but exclusive of cost of repairs of cables, amounted to £15,905. 3s. 2d., leaving a balance of £7,666. 12s 2d. as the net profit of the half year, making with £228. 18s. 8d. brought forward from the previous half year, and £4,246. 9s. 2d. transferred from the reserve fund account a total of £12,142. For the corresponding half year of 1886 the working expenses and other payments amounted to £15,866. 19s. 7d. Three quarterly interim dividends of 2s. each per share amounting to £18,213 have been declared and paid during the financial year, and a final dividend of 2s. per share is now proposed, making, with the three interim dividends 2 per cent. for the year, being a total distribution of £21,284. The interest on the reserve fund will be utilised to provide for this final dividend. A break occurred in the short section of cable on the 4th Feb. last, and was repaired on the 10th of March. On 3rd April the main section of cable was interrupted, and was repaired on 10th of same month. A further break in the short section took place on 13th April, and was repaired on 22nd April. The cost of repairing these three interruptions, including spare cable used, amounted to £5,223. 7s. 3d., which has been charged against the reserve fund as usual. The sixpenny tariff is still in force, and the volume of traffic shows a large increase.

Pursuant to the provisions of the Articles of Association, two of the Directors, viz., John Pender, Esq., and E. M. Underdown, Esq., Q.C., retire by rotation, and being eligible, offer themselves for re-election. Mr. John G. Griffiths and Mr. John Sawyer, the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the half year ended 30th June, 1887, to be presented at the thirty-second ordinary general meeting of shareholders, to be held at the offices of the Company, 61, Old Broad-street, E.C., on the 27th July, 1887, at 1 o'clock:—

From the report it will be seen that the gross receipts (including the balance brought from last account) amount to £21,292. 19s. 6d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £6,552. 8s. 11d., leaving a sum of £14,740. 10s. 7d. to the credit of revenue account. Of this the sum of £4,500 has been added to the reserve fund, increasing that fund to £71,000. The dividend on the preference shares will absorb £3,000, and leave £7,240. 10s. 7d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, the balance, £240. 10s. 7d., being carried forward to the current half year's account. One of the harbour lengths at Cienfuegos having become worn out, a new length has been laid by Mr. Keith, the Company's engineer, to take its place. The main cables have continued throughout the half year, and are at present, in good working order. The Director who retires from the Board at this time is Mr. Joaquin de Mancha, who, being

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eligible, offers himself for re-election. Mr. Thomas Greenwood, the auditor, also retires, and offers himself for re-election.

Submarine Telegraph Company.

Report of the Directors to be submitted at the meeting of the proprietors of this Company, to be held at the offices of the Company, 2, Throgmorton-avenue, London Wall, E.C., on Monday, the 25th inst., at one o'clock p.m. :—

The accounts for the six months ending 30th June, 1887, show a result which enables the Directors to add the usual proportion of the receipts to the reserve fund, and to recommend a dividend at the rate of 12 per cent. per annum, and to carry over a balance of £979. 5s. 1d. to the next account. The dividend for the corresponding period of 1886 was at the rate of 12 per cent. per annum also, and the balance carried over was £523. 5s. 7d. The average length of the messages transmitted in the half year has been 11·06 words, against 11·05 in the corresponding six months of 1886, but there has been an increase of 135,427 messages in 1887 compared with 1886. The total working expenses for the half year of 1887 show an increase of £1,005. 13s. This increase is accounted for chiefly under the heads of "Salaries and Wages," "Repair to Premises," and "Repairs and Insurance of Steamer." The number of accidents to the cables in the two half years has been about the same. All the Company's cables, as well as those worked by the Company, are in good working order. In their last report the Directors stated that the Right Hon. Robert Bourke (now Lord Connemara) had accepted the important office of Governor of the Presidency of Madras, and had in consequence resigned his seat on the Board of Directors of this Company. The Hon. John Stewart Gathorne-Hardy, M.P., had been appointed by the Board to fill the vacancy caused by Lord Connemara's resignation, subject to the approval of the proprietors. The Board recommend the election of Mr. Gathorne-Hardy as a Director of the Company.

Globe Telegraph and Trust Company (Limited).

Report of the Directors to be presented to the shareholders at the fourteenth ordinary general meeting of the Company to be held at Winchester House, 50, Old Broad-street, E.C., on Thursday, the 28th July, at 2 o'clock :—

The net revenue of the Company for the year, after deduction of expenses, amounts to £146,344. 17s. 2d., which, with the balance of £1,564. 6s. 2d. brought forward, makes a total of £147,919. 3s. 4d. From this amount there has been distributed the sum of £100,246. 10s. 11d. in interim dividends, leaving an available balance of £47,662. 12s. 5d. The Directors recommend payment of a final dividend for the year of 3s. per share on the preference shares, and of 2s. 3d. per share on the ordinary shares, making, with the former distributions, a total dividend for the year of 6 per cent. less income-tax upon the preference and 2¾ per cent. net upon the ordinary shares, carrying forward a balance of £1,439 9s. 11d. The reduction of the dividend on the ordinary shares is attributable to the continuance during the current year of the sixpenny traffic rate by the Atlantic Companies, in which this Company holds stocks and shares. Sixty of the shares of the German Norwegian Cable Company have been drawn and paid off at par, and the proceeds have been carried to credit of the capital account. The Company has acquired 400 additional shares in the French Telegraph Company, Paris to New York. By order of the High Court of Justice the preference capital of the Direct Spanish Telegraph Company was reduced from £10 per preference share to £5. In all other respects the Company's investments remain the same as in last year's accounts. In conformity with the Articles of Association, Mr. William Ford and Sir Daniel Gooch, Bart., two of the Directors, retire, but, being eligible, offer themselves for re-election. The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and Mr. William Griffith, B.A., Barrister-at-Law, also retire at the meeting, and offer themselves for re election.

CITY NOTES, &c.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION (LIMITED). The Anglo-American Brush Corporation has issued the following circular to their shareholders :—

Sir,—I am instructed by the directors to inform you that of the 5,000 new shares recently offered for subscription in pursuance of the resolution passed at the last general meeting of the shareholders only 1,354 shares have as yet been taken up. The additional capital thus provided is not sufficient to meet the requirements of the corporation as a result of the acquisition of important undertakings in Austria-Hungary, and of other investments made for the purposes of further developing its business and maintaining and strengthening its position. Having regard also to the fact, already known to the shareholders, that the increasing business of the corporation has for some time past been conducted under disadvantages consequent upon inadequate working capital, the directors have decided that in the best and permanent interests of the proprietary it is desirable to make a call of £1 per share on the shares upon which only £3 per share have been paid. This call will enable the corporation to satisfactorily complete the arrangements already sanctioned by the shareholders for the necessary extension of its manufacturing and other operations, and by placing the finances on a more favourable footing facilitate the carrying out of important contracts. The directors have pleasure in stating that, considering the present depressed state of the electric light industry, the business of the corporation continues to improve in volume, though in face of keen competition and consequent fall of profits it is necessary whilst practising the most rigid economy to secure all the advantages which a command of adequate working capital affords.—I am, Sir, your obedient servant,

E. GARCKE, Secretary.

112, Belvedere-road, Lambeth, London, S.E., 16th July, 1887.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 15th July are £2,331, as compared with £2,741 in the corresponding period of 1886. The March receipts, estimated at £6,599, realised £6,708.

WOODSIDE ELECTRIC WORKS.—Mr. Joseph Davenport Finney Andrews has ceased to have any connection with the Woodside Electric Works, South Woodside-road, Glasgow, which are now under the charge of Mr. Rankin Kennedy.

NEW COMPANIES REGISTERED.

CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—Registered by H. Philpots, solicitor, 25, Bedford-row, W.C., with a capital of £10,000, in shares of £5 each. Object, to carry on the business of an electric lighting, motive power and supply and telephone company in all its branches. The directors shall not be more than twelve nor less than three in number, and the first shall be Mr. Henry Jasper, High-street, Chatham ; Mr. William James Mackey, High-street, New Brompton, and Mr. Charles Thomas Smith, High-street, Chatham. The general manager is Mr. Mark Parker. Qualification, the holding by each of at least 20 shares in the company. Remuneration to be determined in general meeting. The temporary registered offices of the company are at 22, High-street, Chatham.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 20.		BUSINESS DONE WEEK ENDING JULY 20. Highest.		Lowest.	
Anglo-American	37,	38	.....	37½	.....	36½
Do. Preferred	60,	61	.....	61	.....	59½
Do. Deferred	14½,	15½	.....	15½	.....	14½
Brazilian Submarine	11,	11½	.....	11½	.....	11 1-16
Cuba	12,	12½	.....	12½	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2¾,	3	.....	—	.....	—
Do. Preference	7½,	8½	.....	—	.....	—
Direct United States Cable	9,	9½	.....	—	.....	—
Eastern Telegraph	11,	11½	.....	11½	.....	10¾
Do. 6 per Cent. Preference	14,	14½	.....	14 7-16	.....	14
Do. 5 per Cent. Debentures, 1899	107,	110	.....	—	.....	—
Eastern Extension	11½,	11¾	.....	11¾	.....	11¾ xd
German Union	10½,	11	.....	10¾	.....	—
Globe Telegraph and Trust	5¾,	5¾	.....	5 9-16	.....	5 7-16
Do. Preference	13,	13½	.....	13½	.....	13
Great Northern	13½,	14	.....	—	.....	—
Indo-European	34,	36	.....	35½	.....	35
Reuter's	7½,	7¾	.....	—	.....	—
Submarine	180,	190	.....	183	.....	180
West India and Panama	⅝,	¾	.....	—	.....	—
Do. 1st Preference	8½,	9	.....	8¾	.....	—
Western Brazilian	8,	8½	.....	8 3-16	.....	8
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	104,	107	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	.....	—	.....	—
Oriental	½,	⅝	.....	—	.....	—
United Telephone	12,	12½	.....	12⅝	.....	12½ xd

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	2⅛	.....	—
Do. (fully paid)	3,	4	.....	—	.....	—
Swan	1½,	1½	.....	1⅝	.....	—
Maxim Weston	3-16,	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	.....	37	.....	36½ xd
India Rubber, Gutta Percha, and Telegraph Works	23,	24	.....	23⅜	.....	23

THE ELECTRIC APPARATUS COMPANY, Limited.
Head Office and Warehouse: 50, Bow Lane, Cheapside, E.C.
Depots: 4, Charing Cross, S.W., and 65, Faulkner St., Manchester.
Works: Arnold Road, Bow, E.
Electric Light Fittings, Edison-Swan Lamps, Schuckert's Ammeters, Voltmeters and Speedometers.
Specially Low Quotations for Electric Light Cables.
BELLS, INDICATORS, BATTERIES, WIRES, &c.
MEDICAL APPLIANCES.
SHIPPERS AND THE TRADE SPECIALLY STUDIED.
NO CONNECTION whatever with any Firm trading under a SIMILAR TITLE

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NOTES.

BURTON-ON-TRENT.—A telephone exchange has been opened in this town by the National Telephone Company.

PORTADOWN.—We understand that the commissioners of Portadown are making inquiries about electric lighting.

A NEW WEST INDIAN CABLE.—The Spanish Government has authorised the construction of a cable between the islands of Cuba and Hayti.

"THE TELEGRAPH OF THE FUTURE."—This is the title of a work which is announced by Messrs. Trübner to appear shortly. We understand, however, that it deals with "psychic force."

SHIP LIGHTING.—The steamer "City of Aberdeen," belonging to the Aberdeen Steam Navigation Company, is being fitted with electric lighting plant by the Anglo-American Brush Company.

BRUSSELS.—Several large electric installations are now being arranged in Brussels. Amongst the most important are the lighting of the new Military Hospital, the Shaerbeck Railway Station, and at Meiselberke Station.

MARENNES.—Electric lighting continues to make steady progress amongst the towns and villages in the south-east of France, where water power is happily available. The little town of Marennes and the village of Vierza will shortly be added to the list. The contractor is M. Grejbel.

A NEW LUBRICANT FOR COMMUTATORS.—M. Bandsept informs us that he has found that Marseilles soap makes an admirable lubricant for the commutators of dynamo machines. It should be applied in very small quantity, and will be found highly efficacious in preventing the wear of the brushes.

THE TELEPHONE SUITS IN THE STATES.—According to a telegram in the *Standard* judgment has been delivered in favour of the Bell Telephone Company in its suit against the Globe Company, who were making use of Bassano and Slater's instruments. The defence was based upon the supposed priority of Meucci, the Italian inventor.

TRANS-OCEANIC TELEPHONY.—The New York daily papers want to know why their electricians do not lay a telephone cable to Europe. Mr. Barnum, we learn, "is considering the project," and thinks of ordering a special cable to transmit opera from Paris. We venture to recommend Mr. Barnum to study the writings of Oliver Heaviside.

BANK LIGHTING.—The Union Bank of London, who have for a long time past been considering the question of the electric lighting of their new premises in Princes-street, have now placed the work with Messrs. B. Verity and Sons, of King-street, Covent Garden, under the supervision of Messrs. Drake and Gorham, who are acting as engineers for the bank.

PERSONAL.—We understand that Major-General Webber, C.B., has resigned the position of managing director of the Anglo-American Brush Electric Light Corporation, and has accepted the appointment of consulting technical adviser. Mr. Emile Garcke, who for upwards of four years has been the secretary of the corporation, has been appointed manager and secretary.

A NEW INSULATING PLATE.—An insulating plate which, while very thin and light, is absolutely impermeable to moisture and to air, may be made by taking two leaves of tin-foil coated with a thin layer of gutta percha solution (dissolved in benzine or carbon di-sulphide) and placing them face to face, separated by a leaf of thin paper of close texture. This suggestion is due to M. Bandsept.

FRANCE AND OCEAN CABLES.—The scheme for promoting a cable company under the patronage of the French Government to connect the French Colonies in South America with the mother country, referred to at considerable length in our issue of February 18th, pp. 328, 334, has met with another rebuff. The Chamber of Deputies has postponed *sine die*, by a majority of 237 to 208, the first reading of a Bill to form this company.

THE PROPOSED ELECTRIC TRAMWAY AT BRAY.—The opposition to the proposed electric tramway from the terminus of the Dublin, Wicklow, and Wexford Railway Company to the strand at Bray Head having been withdrawn, the scheme has now received the sanction of the Judicial Committee of the Privy Council, and only awaits the approval of the Lord Lieutenant. We understand that the work will be placed in the hands of Messrs. Woodhouse and Rawson.

THE CARBON TRADE IN AMERICA.—We recently mentioned that the makers of electric light carbons in America had formed a combination to raise the price of carbons to remunerative rates. This move has, however, been met by the electric lighting companies of New York, who have issued a circular proposing the formation of a committee representing the whole of the arc lighting companies to consider the advisability of undertaking the manufacture of their own carbons upon a mutual basis.

SWANSEA.—The Western Counties and South Wales Telephone Company have now extended the Bristol-Cardiff trunk line as far as Swansea, a total length of 116½ miles. The line will shortly be carried on to Llanelly, 12 miles further. At present only a single wire has been completed between Swansea and Cardiff, and that portion of the line is worked through an earth return. In another fortnight, however, it is anticipated that the metallic circuit will be complete throughout. In the meantime conversation between Bristol and Swansea is even now carried on without difficulty.

THE TAMINE ACCUMULATOR.—M. Tamine, of Brussels, has devised an accumulator of the Planté type, in which the liquid consists of a saturated solution of sulphate of zinc, to which is added 50 per cent. of sulphuric acid, 5 per cent. of sulphate of ammonia and 5 per cent. of sulphate of mercury. In making up the cell it is stated that the ingredients should be poured in in the reverse order to that here enumerated. The E.M.F. of the cell is given as 2·3 volts. The addition of sulphates of mercury and ammonia is said to prevent the formation of sulphate of lead on open circuit. The solution appears to be practically identical with that employed in M. Mezerolle's cell.

MALTON.—The Malton proposals have resulted pretty much in the way which might have been anticipated after reading the details which we gave in our last issue; that is to say, out of twenty-four firms who examined the specification of the borough surveyor not a single one proceeded to tender. This result is far more satisfactory than the recurrence of any catch-penny offers such as have too often been made. The Gas Company offered to provide the stipulated number of burners, to consume 5ft. of gas per hour, and to burn 1,700 hours per annum, at a yearly rate of £2. 3s. 6d. per lamp. This offer led to a heated discussion, and the matter still remains unsettled.

PARIS.—It is reported that the Edison Company has applied for powers to open a central lighting station in the neighbourhood of the Théâtre Français. MM. Davy Lepage and Cie. are also negotiating for the establishment of a station in the Boulevard de Strasbourg.—The Paris General Telephone Co. has contracted for supplying the Buenos Ayres Telephone Co.,

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just formed, with all the requisite instruments, material, and plant for the establishment of the telephone system in the Argentine capital. The Paris Company has also received an order for cables from the Buenos Ayres Municipality, the latter having decided to make an experiment in lighting the city by electricity.

WHAT IS A "SELF-REGULATING" DYNAMO?—A correspondent is anxious to be informed "whether a patent compound-wound self-regulating dynamo-electric machine, in which the brushes are shifted by hand for variable loads, and an adjustable resistance is placed in circuit with the shunt coils, may be considered to possess any marked superiority over machines in which these features are absent?" After carefully considering this curious point raised by our correspondent we are inclined to reply to his question in the negative. But as we are aware that other views are held by (presumably) high authorities, we cannot ask him to attach too much importance to an editorial opinion.

MEETING OF THE INSTITUTE OF MECHANICAL ENGINEERS.—The summer meeting of the Institute of Mechanical Engineers will be held in Edinburgh, on Tuesday morning, August 2, and Wednesday morning, August 3, in the University. The chair will be taken at half-past nine o'clock by the President, Mr. Edward H. Carbutt, in the Natural History Lecture Theatre. The following amongst other papers have been offered for reading and discussion:—"A Description of the Electric Light on the Isle of May," by Mr. David A. Stevenson, of Edinburgh; "On Electro-Magnetic Machine Tools," by Mr. Frederick John Rowan, of Glasgow; "On the Position and Prospects of Electricity as Applied to Engineering," by Mr. William Giepel, of Edinburgh.

SECONDARY BATTERIES IN BELGIUM.—We understand that a syndicate has been formed at Brussels with a view to the acquisition of the whole of the Belgian patents (of any practical importance) relating to secondary batteries. It is believed that arrangements will be concluded with most of the present holders on the basis of an average royalty of two centimes per kilogramme of plates manufactured. The principal object in view is to unite all the valuable features at present distributed amongst numerous patents so as to obtain the best possible form of cell free from all patent troubles and trials. This is a sensible idea, and we shall hope to hear that the negotiations have been carried to a successful issue in time for the International Exhibition which is to take place next year at Brussels.

THE BRUCE ELECTRICAL WAR BALLOON.—On Monday evening last Mr. E. S. Bruce exhibited his electric war balloon at the Kensington Town Hall. The apparatus is intended for aerial signalling. The balloon is of varnished cambric, with a capacity of 2,000 cubic feet. The interior contains a frame, in the form of a ladder, suspended in its centre, holding six incandescent lamps of the Edison and Swan type, of 25 volts, the current being conveyed to the frame by a flexible double cable. The lamps are controlled from a switch board, the contacts being of carbon instead of platinum, and the balloon is held captive by a line of Italian hemp capable of bearing a breaking strain of 25 tons. The apparatus is worked with an E.P.S. battery of 25 cells. We understand that the trials which have been made at Chatham have convinced the military authorities of the utility of the idea. The apparatus exhibited has been made for the Belgian Government.

THE PARIS, 1889, EXHIBITION: PROPOSED NOVEL ELECTRIC RAILWAY.—In a paper read by M. Eugène Hénard before the French Society of Architects, it has been proposed to lay down a "continuous" electric railway or "carrying platform" around the whole of the grounds of the Paris Exhibition. The idea is to lay the rails in a trench of such a depth that an ordinary flat-topped railway waggon just reaches the surface of the ground; the whole circle would then be filled with a train of such waggons coupled close together and provided with a continuous floor. This train is to be driven at a walking pace by a number of electric motors placed at intervals upon or underneath the waggons. Passengers can thus step on or off at any point, and no fares would be charged except for seats. The working of the line would be controlled from signal boxes placed at suitable distances, from each of which the train may be stopped at any moment by opening one of the main leads. The idea strikes us as a rather good one, and there should be no difficulty in carrying it out with entire success, and with great convenience to visitors.

SEILER'S HOTEL ANNUNCIATOR SYSTEM.—In order to reduce the number of electro-magnetic drops which are required in fitting a large building with electric bells and annunciators, Mr. P. Seiler (of San Francisco) has brought out a system whose merit consists chiefly in the use of a limited number of annunciators to indicate a much larger number of rooms. This is carried out by placing the numbers of the rooms on fixed tablets arranged in a square or rectangular form, and having two rows of annunciators which run along the top and down one side of the board, so that by the fall of any two of the annunciator drops a particular number is indicated. The arrangement for actuating the drops is ingenious. When a call is first received an annunciator in the horizontal row only is seen to fall. The signal is then acknowledged by the attendant, who presses the key which is found at the bottom of the vertical row of numbers indicated by the drop. The pressing of this key causes the second drop in the vertical row of annunciators to fall, indicating the number of the room, and at the same time giving an acknowledgement of the signal.

METHOD OF PREVENTING THE BLACKENING OF INCANDESCENT LAMPS.—Mr. Ed. P. Thompson has found that the blackening of the glass of incandescent lamps is chiefly due to the carbon particles which are driven off on first closing the circuit when the filament obtains a static charge. In order to avoid this Mr. Thompson has made lamps in which the filament surrounds a loop or stem of copper wire, which passes through the stem of the lamp and is connected to earth; the wire being also provided with several points which project towards the filament. The result is that when the static charge is received the carbon molecules tend to be projected upon the wire, and the blackening of the glass is prevented. Mr. Thompson's theoretical explanation of the effect is certainly sufficiently plausible to merit consideration, but it appears to us that if this view were correct it would follow that incandescent lamps supplied with alternating currents should blacken much more rapidly than with continuous currents, and their life should be much shorter. We have not learnt that such a result has ever been observed, and it would almost appear that this objection is fatal to the static charge theory.

HOW TO FORM A PRIMARY BATTERY COMPANY.—The following instructions upon this interesting and important subject are taken from an American technical journal. The business appears, however, to be tolerably well understood in certain quarters on this side the Atlantic:—"Organise under the laws of the State of Maine; 10,000 shares of stock, par value, $100 per share. Offer to let in your friends on the ground floor at $1 per share. Print some circulars, setting forth the millions [not] made in primary batteries, in times

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gone by; explain indefinitely that a new discovery has been made of an [old] chemical by the aid of which current can be produced for domestic incandescent lighting. There are as gullible investors as ever were caught, and they will bite. Delays are convenient—carbons not ready; cups too porous. Keep this up as long as possible, and then get some batteries, and run one or two incandescent lights far above their candle power. Do not let them burn but a few moments at a time, and a 5 candle-power run up to 25 candle-power will last some days. Comment on the whiteness and steadiness of the light. When people apply for batteries convince them of their folly, and induce them to purchase stock. When the enthusiasm is at its height sell the stock, and be conveniently called to some other section of the world for a year. On returning repeat the same operation."

VULCABESTON.—Vulcabeston is the name of a new material which professes to combine all the valuable qualities of asbestos and india rubber. It is described as forming a substance of the toughness of horn, although it can be made of any degree of flexibility. It is a non-conductor of electricity, and stands the severest test of acids, steam, gases, &c. One of the most important uses of the new material is as a moulded piston rod packing ring, made to fit any sized rod or stuffing box, and to be sprung in place with a slight pressure, one or more rings being used as desired, and forming a perfectly tight steam joint. These rings do not wear the rod, and they are self-lubricating. The first set made of these rings has been in use over eleven months, in a Hartfort, Conn., manufactory, on an engine run at 280 strokes per minute, and is still in perfect order. Vulcanised asbestos piston rod packing in the form of flexible rope, of all sizes, will not shrink or blow out, and is especially adapted for use on locomotives and ocean steamers, and in other places where loss of time in repacking is of the greatest consequence, and where the use of ordinary steam packings would consequently be entirely inadmissible. And it is claimed that in consequence of its great strength and durability it can be used wherever metallic packings have heretofore been necessary. If all this is true the new material may be expected to do good service in connection with engines for central station electric lighting.

GALLANT CONDUCT OF TWO ELECTRICIANS.—We have pleasure in recording two very gallant rescues from drowning which took place last week at Waterford, and of which Messrs. Pope and Bate, of the firm of Laing, Wharton and Down, were the heroes. These gentlemen are at present engaged in the erection of a Thomson-Houston plant for lighting the City of Waterford, and were bathing in the bay on Thursday morning, although the water was somewhat rough. On the left hand side of the bay a strong under-current exists, and after being in the water some time Mr. Bate observed a man in an unconscious condition and drifting out to sea in the current. Shouting to his colleague, they both dashed to the rescue. The drowning man was first reached by Mr. Pope, who, after an exhausting struggle for ten minutes in the heavy seas, brought him safely to land. Mr. Pope found himself completely done up and unable to stand, but while being attended to by Mr. Bate, cries were again heard from the sea, and a priest, Father Dooley, was discovered vainly endeavouring to support another half-drowned individual whom he had gone to rescue. Mr. Bate seized a life-buoy, and again plunging into the water, succeeded, with the aid of a bystander named Phelan, in bringing both men safely to shore. The individual saved by Mr. Pope was a medical student named Keogh, and in the second case Mr. O'Farrel, a ship-broker, was concerned. We are glad to hear from Messrs. Laing, Wharton, and Down that they are taking steps to bring the matter before the Royal Humane Society.

THE PARTNERSHIP BETWEEN GAS AND ELECTRICITY IN AMERICA.—The annual report of the American Electric Manufacturing Company contains the following reference to their alliance with the gas interest:—"The past year has demonstrated the soundness of the opinion long entertained and persistently advanced by the officers of this company, that the gas and electric lighting interests of the country should co-operate instead of antagonising each other. Gas lighting companies have finally come to recognise the fact that their interests are best subserved by the combination of the two illuminants for local lighting purposes under one management, and that it is far better for them to add electric lighting apparatus to their present plants, and thus prepare themselves to meet the entire demand for illumination in their respective localities than to permit others to introduce the newer and more brilliant illuminant as a rival to gas. They have found that such a combination is not only practicable and profitable, but that the adoption of electric lighting by gas companies practically excludes competitors because of the superior economy with which such companies can operate electric lights in connection with their established gas business. Other electric lighting companies have at last perceived that the combination is inevitable, and are tardily endeavouring to obtain the adoption of their respective systems. But the American Company is pretty generally recognised as the pioneer in this direction, and will naturally enjoy the largest share of the patronage of the gas companies, especially in view of the superiority of its apparatus. Recognising the great importance of the company's future dealings with this extensive and important industry, the trustees established a special gas department of the company's business, and have placed in special charge thereof one of the most experienced, successful, and widely known gas engineers in the country."

ELECTRIC TRACTION.—Considerable light is shed upon the causes of the very partial success of electric traction on the Brussels tram lines when we learn that an attempt was made to use a dynamo of old-fashioned type as a motor. Upon the long and steep gradients of the Brussels line the torque upon the armatures must be very great indeed, and it was little short of folly to expect an armature built for a totally different purpose to withstand the strain. Whatever points of divergence have yet to be settled in the theory of dynamos and motors, it is yet fully understood—or at any rate it is high time that it should be—that a motor which is geared in a positive manner, and is liable to be started under a heavy load, must be designed, both mechanically and electrically, on the basis of an output far exceeding its normal rate of working. An old-fashioned dynamo is simply useless for work of this description. The Brussels Company having now fully convinced themselves upon this point, we understand that it has been decided to employ motors of English make, and M. Julien was recently in this country making inquiries. We are pleased to learn that the Julien cells continue to give satisfaction. Each car, weighing with its load of passengers 16,500lb., carries in addition a weight of 3,300lb. of accumulators. This ratio of weight of battery to total weight is slightly lower than that obtained by the Electric Traction Syndicate (as described in another column), but this in part arises from the fact already alluded to, that the motor is too light for its work. But as we are not aware of the total capacity of the cells in the former case, the comparison is not of much value. The battery consists of 120 cells, which are coupled to a switch, so as to

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give 60, 120, 180, or 240 volts, as may be desired. The plates are reported so far to have behaved very well indeed. We trust that the present suspension of the service will not be of long continuance, and we fully anticipate that with suitable motors the success of the company will become indisputable.

THE ELECTRIC LIGHT IN THE FAR WEST.—In the smaller towns of the Western States of America the electric light continues to make steady progress, and its introduction is greeted with an enthusiasm which is positively delightful. The *Roodhouse Evening Eye* thus describes the first lighting up of an arc lamp plant in the streets of its native town, and it must be said that the writer rises to the height of the occasion: "A few moments of breathless expectation, and a great cheer goes up as the carbons break into flame, as with the quickness of lightning the dazzling arcs of flame burst forth between the carbon points, as if the genius of electricity, angry to find his course opposed, had leaped the barrier, white with rage. The effect was wonderful, and far exceeded the expectations of all. It was well calculated to arouse enthusiasm." After this it was of course impossible to refrain from "dropping into poetry." Here is the result:—

PANSY'S PIECE.

No more in darkness will we grope
  Along the gloomy street,
And on a narrow walk collide
  With every one we meet.
The wonderful electric light
  Our highways will illume,
While all the towns for miles around
  Are talking of our boom.
Behold it gleaming in the sky,
  With scintillations bright,
Like some resplendent jewel in
  The shirtfront of the night.
The pale moon shines with sickly hue,
  And hides her yellow face,
The spark electric rules the night,
  And has usurped her place.
And burning Phœbus, lord of day,
  When this new sun he sees,
Withdraws himself to other parts,
  And shines on the Chinese.

POROUS CELLS MADE OF VULCANISED FIBRE.—According to our contemporary, *L'Electricien*, it has recently been discovered by M. de Rufz that notwithstanding the excellent insulating properties of vulcanised fibre when dry, yet after long soaking in "a liquid" (whether pure water or not does not appear) it swells considerably and becomes very sensibly porous, so much so as to be admirably adapted for use in two-fluid primary batteries, or in secondary cells of the Faure type as a separator between the plates. For each of these purposes it is said to be well adapted, because of its very low electrical resistance. We may, however, remark that the apparent resistance of a porous pot is in reality the resistance of the liquid which it contains in its interstices, and therefore varies with the nature of the liquid in which it has been soaked. Hence the measurement of the apparent resistance of a porous pot is an index of the rate at which liquids can diffuse through its walls, so that for primary batteries there will in some cases be a limit below which it is not advantageous to reduce the resistance of the cell. On the other hand, for secondary batteries, and also for primaries used in electric lighting, where the liquids are presumably exhausted before much diffusion can have taken place, the new material seems to give promise of usefulness. At the Ecole de Physique it was found that the internal resistance of a Bunsen cell, which measured ·06 ohm, with an earthenware pot, was reduced to rather less than 0·03 ohm on the substitution of a vulcanised fibre cell ½ mm. in thickness. One advantage cells of this description would undeniably possess, that is, in the reduction of weight, and M. de Rufz attaches considerable importance to this point as facilitating the employment of primary cells for the propulsion of tricycles, balloons, and boats. It is, however, necessary to add this caution; vulcanised fibre dissolves rapidly in the solutions of certain salts, amongst which are the bichromates of potassium and of sodium, and it is also attacked by concentrated sulphuric acid, although in the dilute acid it remains unaffected.

LEAMINGTON.—The engine and boilers for the Leamington central station are now in place, and the dynamos (of the Chamberlain and Hookham type) will shortly be ready. The contract for laying the underground cables is in the hands of Mr. J. Fell, and considerable difficulty has been experienced owing to the number of gas and other pipes already in the ground. We understand that a satisfactory number of applications has been received, and it is hoped that the installation will be at work before the end of August.—On the 27th inst. Major-General C. Phipps Carey, one of the Local Government Board inspectors, held an inquiry at Leamington respecting the application of the Town Council for leave to borrow three sums of £1,033, £1,230, and £500. Mr. Passman explained that the loan of £1,230 was required for electric lighting purposes. The council had entered into arrangements with the Electric Lighting Company for lighting the Parade, the Town Hall, Free Library, and Pump Rooms. It was not proposed to dispense with the present arrangements for the supply of gas, so that if the electric light should not prove satisfactory they could revert to gas. Their contract with the gas company included their right to experiment with any new light which may be brought out, and, on the other hand, their agreement with the Electric Lighting Company could be terminated at the close of 1888 if desirable. The Corporation paid none of the cost of the machinery and apparatus for supplying the electric light. They only paid for their connections and their lamps. The loan included £475. 11s. 6d. for the Town Hall and Free Library, £212 for the pump rooms, and £542. 10s. connected with the lighting up the Parade from the bridges in Bath-street up the Parade to Christ Church, a distance of about a quarter of a mile. As proof of the *bona fides* of the Electric Lighting Company, Mr. Passman said they were expending upwards of £10,000 upon their works. Mr. Gilbert said the total outlay for this company would be nearly three times the amount named by Mr. Passman. The quality of the light to be supplied to the public buildings, Mr. Passman explained, would be sixteen candle-power, and the cost at the rate of 4d. per Board of Trade unit of 1,000 volt-ampere hours. The inspector will report to the Local Government Board in due course.

BURNING OF THE TELEPHONE EXCHANGE AT PITTSBURG.—On the morning of the 10th inst. a fire broke out in a block of buildings at Pittsburg occupied by the Telephone Company, the Western Union Telegraph Company, and the Printing Telegraph Company. The telephone exchange was completely destroyed, the whole of the instruments and batteries of the Western Union Company were burnt, and much damage was done to the plant of the Printing Telegraph Company. It is not known how the fire originated, but it was first discovered under the Western Union switch-board, and it is supposed that rats or other vermin had eaten off the paraffin and cotton covering, leaving the bare wires in contact with woodwork. An alarm was sent in from two boxes, and the fire department

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responded promptly, but as the flames were in the upper floors, which were surrounded by a labyrinth of line wires, the firemen were much hindered by having to cut their way to the building. There were eight to nine thousand cells of battery on the top floor, and these played an important part. In Pittsburg the almost obsolete practice of filling up battery cells with signal oil was followed, about eight barrels of it being used in the room. This oil, of course, caused the fire to burn more fiercely and rapidly, while the fluids from the broken batteries poured down the inside and outside of the building, staining everything a dirty yellow. The telegraph company immediately transferred their business, so far as possible, into the eight circuits of the Mutual Union, and ordered a carload of supplies express from New York. In four days they had all their wires working. But with the telephone company such promptness in resuming business was impossible, because outfits for telephone exchanges are made to order, and cannot be had on very short notice. One of the eight sections of 2,000-wire multiple boards was ruined, and the other seven had to be taken apart and sent to Chicago for repairs. The exchange at Pittsburg is the third large telephone exchange in America that has been destroyed by fire, the others being Montreal and Toronto. After the burning of the Toronto exchange it was suggested that, in view of the delay in getting large switch-boards in emergencies, it would be a wise thing in the way of insurance if a number of telephone companies should jointly buy a complete central office outfit, to go to the first place burned out. The plan was favourably considered, but no action has been taken.

THE TELEPHONE STATISTICS OF EUROPE.—The International Bell Telephone Company has compiled the following list, which shows the number of telephones in use at the end of 1886 in the countries in which it operates :—

Belgium.

Brussels	998	Le Louvière	22
Antwerp	1,043	Liége	438
Charleroi	216		
Ghent	419		
Verviers	396	Total	3,532

Total length of line wire, about 6,900 kilometres.

Holland.

Amsterdam	1,263	Arnheim	127
Rotterdam	630	Haarlem	69
The Hague	197	Dordrecht	143
Utrecht	129		
Groningen	65	Total	2,623

Total length of line wire, about 3,700 kilometres.

Russia.

St. Petersburg	1,080	Odessa	525
Moscow	690	Lodz	209
Warsaw	533		
Riga	403	Total	3,440

Total length of line wire, 9,550 kilometres.

Italy.

Milan	1,089	Leghorn	372
Genoa	950	Naples	873
Turin	614	Palermo	478
Venice	216	Catania	215
Rome	2,022	Messina	159
Florence	721		
Bologne	364	Total	8,073

Total length of line wire, about 12,500 kilometres.

The largest increase of subscribers was in Belgium, about 18 per cent., and in Russia about 15 per cent., as compared with the figures of 1885. The other countries show less progress. The average increase of all the towns which are worked by companies allied with the International Bell Telephone Company (Limited), of New York, is about 10 per cent., against 9 per cent. in 1885, and 9 per cent. in 1884. In the above-mentioned countries there are, besides, a certain number of minor telephone exploitations. Thus, we find in Belgium seven small towns with telephone exchanges, having a total of about 550 subscribers. In Italy there may be twelve such small towns with the telephone, about which no reliable data can be obtained. In Russia six other towns of more or less importance have telephone installations, whose number of subscribers may be put down as 600 in the aggregate up to the end of 1886.

THE CONDUCTIVITY OF WIRES.—In an interesting paper presented by M. Mialaret to the *Société Internationale des Electriciens*, the author points out that our measurement of the specific resistance of wires of different metals is open to some ambiguity, unless it is stated whether we refer as a standard to a wire of given length and sectional area, or of given length and weight. In this country samples of copper and bronze are frequently referred in the trade both to the foot-mil. and foot-grain as determined 30 years ago for "pure" copper by Mattheissen, the result being that, when the comparison, as is most usual, is made by weight, improved processes now frequently enable manufacturers to turn out wire of 101 or 102 per cent. conductivity. But the improvement in wires of so-called "high conductivity" results, as a matter of fact, as much or even more from the greater density which can now be given to the metal as from its greater purity. It follows that comparisons with the two standards of weight and volume no longer agree amongst themselves, since the density of the metal differs so considerably from that of pure copper. In fact, the actual conductivity of the wire referred to unit volume in many cases *considerably exceeds* the quotation taken with reference to the standard of weight; and although it is much more convenient to weigh a quantity of wire than to ascertain its length by actual measurement, yet it is evident that unit volume rather than unit weight is the proper standard of reference; not only is it the recognised theoretical standard, but it is usually of more immediate practical importance. The divergent results given by the two standards of reference are well illustrated by the following table of measurements, by M. Mialaret, furnished by three different samples of wire of high conductivity :—

	1.	2.	3.
Specific gravity	8·897	9·32	9·6
Conductivity for equal volumes.	102·4	106·7	110·8
„ „ „ weights..	101·7	101·2	101·6

These percentage conductivities are taken in reference to Matthiessen's standards. It would appear from this that manufacturers may be unwittingly doing themselves an unjustice in the statement of percentage conductivities. The remedy is simple enough; the employment of percentage quotations is utterly unnecessary, and is a mere survival from the period before any uniform standard of resistance had been accepted. All we want to know is the actual resistance in ohms of a given volume or a given weight of wire of given sectional area, and at a definite temperature. If, however, the standard of weight be preferred, then it is necessary for purposes of comparison to know also the specific gravity of the metal. We should thus at once get rid of the unscientific and somewhat absurd method of quoting 101 per cent. conductivities, while the uniform quotation of actual resistance will often save calculation. It is true that in this country many of the leading firms already follow this method, but it is still by no means universal abroad, and in any case M. Mialaret will have done good service in calling attention to the discrepancy between the two different customary standards of reference.

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Like some resplendent jewel in
  The shirtfront of the night.
The pale moon shines with sickly hue,
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And burning Phœbus, lord of day,
  When this new sun he sees,
Withdraws himself to other parts,
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POROUS CELLS MADE OF VULCANISED FIBRE.—According to our contemporary, *L'Electricien*, it has recently been discovered by M. de Rufz that notwithstanding the excellent insulating properties of vulcanised fibre when dry, yet after long soaking in "a liquid" (whether pure water or not does not appear) it swells considerably and becomes very sensibly porous, so much so as to be admirably adapted for use in two-fluid primary batteries, or in secondary cells of the Faure type as a separator between the plates. For each of these purposes it is said to be well adapted, because of its very low electrical resistance. We may, however, remark that the apparent resistance of a porous pot is in reality the resistance of the liquid which it contains in its interstices, and therefore varies with the nature of the liquid in which it has been soaked. Hence the measurement of the apparent resistance of a porous pot is an index of the rate at which liquids can diffuse through its walls, so that for primary batteries there will in some cases be a limit below which it is not advantageous to reduce the resistance of the cell. On the other hand, for secondary batteries, and also for primaries used in electric lighting, where the liquids are presumably exhausted before much diffusion can have taken place, the new material seems to give promise of usefulness. At the Ecole de Physique it was found that the internal resistance of a Bunsen cell, which measured ·06 ohm, with an earthenware pot, was reduced to rather less than 0·03 ohm on the substitution of a vulcanised fibre cell ½ mm. in thickness. One advantage cells of this description would undeniably possess, that is, in the reduction of weight, and M. de Rufz attaches considerable importance to this point as facilitating the employment of primary cells for the propulsion of tricycles, balloons, and boats. It is, however, necessary to add this caution; vulcanised fibre dissolves rapidly in the solutions of certain salts, amongst which are the bichromates of potassium and of sodium, and it is also attacked by concentrated sulphuric acid, although in the dilute acid it remains unaffected.

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THE JUBILEE OF THE ELECTRIC TELEGRAPH.

Fifty years ago, on July 25th, 1837, a few scientific men carried out a successful experiment between Euston and Camden Town, which was repeated the next day before a larger audience. From such a small beginning has grown the wonderful network of land telegraphs, of submarine cables, and of telephone lines that we see around us. Familiarity in this case has certainly led the general public to take for granted "what is is right," and to forget, to a great extent, how and by whom such grand results have been obtained.

On Wednesday last a dinner was held at the Holborn Restaurant under the presidency of the Postmaster-General, the Right Hon. Henry Cecil Raikes, M.P., to celebrate in the approved English fashion the Jubilee of the Electric Telegraph. The thanks of the telegraphic world are due to Edward Graves, Esq., C. H. B. Parey, Esq., C.B., and to W. H. Preece, Esq., F.R.S., for the initiative they took, and the unceasing efforts they made to worthily celebrate this anniversary. It is not necessary here to refer to the work of the executive committee or the general committee. That the work was well done the result testifies. Of all the gatherings held in this year of grace 1887 it is probable that none will be of greater historic interest, or will live longer through the endless vista of time than the one we now record. Elsewhere we give a complete list of all those who took part in this memorable dinner. It may be that a few names are given in error as of those present, the list being taken from the amended list of the executive committee just previous to the commencement of the dinner, and at the last moment some who had accepted found it impossible to attend. Our endeavour is to place on record the name of each person who took part in this Jubilee celebration, and we think telegraphists in years to come will look back with interest upon the list.

Lack of space prevents our commenting upon the work of individuals; but it may be accepted that this was a thoroughly representative assembly. A few celebrated workers, whom their colleagues would have been delighted to honour, were from various causes not able to be present, an unavoidable circumstance much to be regretted.

At the conclusion of the dinner Mr. W. H. Preece, F.R.S., announced that letters of regret had been received from the following gentlemen:—Marquis of Salisbury, Lord John Manners, Viscount Cross, Mr. W. H. Smith, Sir Henry Holland, Sir Wm. Grove, Sir Daniel Gooch, Sir Julian Goldsmid, Sir Algernon Borthwick; M. Mascart, Paris; M. Coulon, Paris; M. Fribourg, Paris; M. Delarge, Brussels; M. Koller, Budapesth; and M. Hofstede, The Hague.

Other letters and telegrams of congratulations and regret were referred to, of which we give the following:—

DEAR SIR: Your favour of the 1st, by which you have transmitted me an invitation of the General Committee to a dinner at the Holborn Restaurant, London, on the 27th, in memory of the 50th anniversary of the first practical application of electricity to telegraphy in England, has been duly received.

Thanking you most heartily for the honour thus shown me, I must to my utmost regret add that the unsatisfactory state of my health prevents me from venturing upon a sea voyage. I shall, therefore, miss the beautiful and momentous festivity in the fatherland of Cooke, Wheatstone, Thomson, Hughes, Daniell, Grove, and numerous others, whose names are for ever associated with the rise and progress of telegraphy. Unwillingly I must forego the opportunity to shake hands with many dear old friends and excellent colleagues. But though absent in body, I will be there in mind, and from my heart send you my best wishes. I may ask you to give my compliments to the President of the Jubilee, my esteemed colleague, the Right Hon. Cecil Raikes, M.P.

Please accept my apologies for tarrying so long with my answer, and believe me to be, yours truly,

Berlin, W., July 21st, 1887. DR. V. STEPHAN.

SIR: I have the honour of acknowledging the receipt of your letter of June 30th, inviting me to the dinner which is going to be held on the 27th of this month, in celebration of the fiftieth anniversary of the first practical application of electricity to telegraphy in England; and in reply, I beg to say that much as I desire to assist personally on so noteworthy an occasion, I find, to my very great and sincere regret, that I am unable to give myself that pleasure in consequence of other pressing engagements, which, unfortunately in this instance, admit of no postponement. I beg you will kindly accept my assurance, therefore, that were it not for these circumstances, I would gladly have availed myself of your invitation, for which I tender you herewith my sincere thanks; and I remain, Sir, your most obedient servant,

Berlin, 12th July, 1887. DR. WR. SIEMENS.

"Pray accept heartiest congratulations on Jubilee of the telegraph in England. The progress of telegraphy on this side of the globe has comparatively been no less wonderful than that in the old country during the thirty years which have elapsed since the opening of the first line, seven miles long. In New South Wales only we have erected 20,797 miles of wire, and our returns last year show that we transmitted 2,661,126 messages, which yielded a revenue of £158,127. The number of our stations is 425, and 1,200 hands are employed in the administration of the department. The lines connecting the colony with Victoria and Queensland are worked on the quadruplex system—that system is also adopted on many of our local circuits; the line to South Australia is duplex. In telephony, which is a branch of the telegraph department and entirely in the hands of the Government, our list of subscribers numbers 735; last year's revenue from this source amounts to £1,740.

"Our railway telegraphs include 203 stations and 2,500 miles of line on the section. On double lines where the traffic is very heavy Preece's block system is operated with a success which cannot fail to gratify the eminent and genial inventor. Whilst our material progress has thus been advancing by rapid strides, there has sprung up amongst us and grown into vivacious maturity that brotherhood of feeling towards our fellow-workers throughout the world which seems characteristic of telegraph men; but the line of least resistance, and therefore that which carries the greatest share of the current of our sympathy, is that which connects us with the land whence so many of us have come, and which, although separated by great spaces of time and distance, is yet thought and spoken of by us as the dear old home where telegraphy now holds its first Jubilee. "CRACKNELL, Sydney."

"Many and heartiest congratulations on the Jubilee of the electric telegraph from myself and co-workers in South Australia. In fifty years this offspring of science has, in the direction of peace, revolutionised the whole world, brought the most distant portions of the British Empire within speaking distance, and rendered federation not only possible, but easy of accomplishment. May the circuit which now unites us ever promote the kindest feelings in the large army of British telegraphists, and insulate us from all harm! South Australia, unaided, electrically bridged over the Australian continent, and with a population of but little over 300,000, has erected 10,300 miles of telegraph at a cost of £1,101,477, including buildings. God save the Queen! "C. TODD, Adelaide."

"Agent, Adelaide, to Preece.—From JAMES, Melbourne:—Telegraphs established Victoria, March, 1854, being first south of line; year 1886, over 2,000,000 messages transmitted; revenue, £102,000; miles wire, 15,000; cost construction, £450,000; tariff, six pence minimum six words, penny additional word, address and signature free; number stations, 467; staff, over 2,000. Population 1854, 312,000; 1886, 1,003,000. Congratulations."

"The British electricians in the United States, with American friends and associates, send hearty congratulations and greetings to company assembled to celebrate this day the memory and work of Cooke and Wheatstone and the Jubilee of the Telegraph. All rejoice in an anniversary which finds New York as near to London as Camden Town was to Euston-square 50 years ago, and which sees the great name of Wheat-

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stone honoured the world over in connection with inventions that have made nations neighbours, that have broken down prejudice, and promoted knowledge, friendship, and peace to the whole universe. God bless Old England!

"GEO. G. WARD, for the Committee.

"New York, July 27th, 1887."

"The birth of the Indian Telegraph occurred in May, 1839, when O'Shaughnessy, experimenting in Calcutta, worked an electromagnetic needle, a chemical recorder and two synchronous alphabetical dials through an iron wire line of 23 miles; it is thus 48 years since he started India well in the race for Jubilee honours, and the Indian Telegraph Staff send hearty greetings, and join in your celebration to-night.

"SIR ALBERT CAPPEL."

"Tasmania.—Telegraph: 1,151 miles of poles, 1,730 miles of wire, 109 stations, Morse instruments, telephones, brake combination. Exchanges: Hobart, 200; Launceston, 162. Members heartily join in celebration of Jubilee."

"Your Antipodes sends congratulations. May Macaulay's prophecy never be realised!

"C. LEMON, Wellington, New Zealand."

"GAHAN, of Perth, Western Australia, joins in Australian congratulations on Jubilee."

"From KINGSFORD, Lima.—Members of Society of Telegraph-Engineers and Electricians in Mexico and Peru desire heartiest Jubilee greetings."

"Congratulations from Queensland. Through to Cape York next month, 1,870 miles, all the way for a shilling."

"Eckert to Preece.—Pray accept for yourself and the other members of the telegraphic fraternity who are present the warm congratulations of Dr. Green and myself on the occasion of your Jubilee dinner. We who are so busily engaged in the development of the telegraph are perhaps the least conscious of the multitude of blessings which have followed and which still follow in its train. We cannot divest ourselves of the arduous toil and the exacting details which have marked its progress step by step, and which spoil for us the complete perspective of the great results which have been achieved. It, however, seems almost incredible that my practical experience should cover a period which began with short circuits that succumbed to almost every summer shower, and has now reached a point when we frequently send, almost irrespective of weather, about 50,000 words in the evening over direct circuits nearly 4,000 miles long for publication in the San Francisco papers the next morning. In fifty years the telegraph in America has grown to the gigantic proportions of the Western Union Company—that is, 475,000 miles of wire, or enough to girdle the earth nineteen times. This development has enlisted the endless endeavour of some of the brightest intellects of the age, and represents everywhere an equal indebtedness to the untiring loyalty and zeal of the rank and file of the telegraphic profession. The telegraph has been one of our greatest pioneers wherever man has gone. Into the wilds in search of treasure, or to cultivate the soil, he has taken it with him. At first it has supplied his necessities nearly as soon as they have arisen, and then it has brought him luxuries almost as soon as he has desired them. While the railroads have been the means of quicker transportation, the telegraph has been, if I may so call it, the nervous intelligence which has informed their movements, enlarged their facilities and enriched their results. In a few months by these means towns have sprung up in the virgin forests or on the desolate plains, and in a few years they have by the same means developed into opulent cities, giving prosperity and contentment to thousands. Add to this the achievement of submarine telegrapy, and are we not identified with, and, in fact, part and parcel of, one of the greatest powers for good not only of this marvellous nineteenth century but of all time? The kinship of nations has been strengthened by the telegraph, and most of all between England and America the incessant streams of messages across the Atlantic bear silent witness to the bonds of affection, sympathy, and interest which bind the two peoples together. The next generation of telegraphers will start with results which were undreamed of to us in the infancy of the art. Let us hope that they will not disdain to remember with some degree of interest and sympathy the debt which their perfection owes to the perplexities, bordering sometimes on despair, which accompanied the early efforts of the senior ranks to which you and I belong.

"ECKERT."

The CHAIRMAN, who was received with prolonged cheers, then said: Gentlemen—The first toast upon every public occasion of this kind during every year of the long reign among her faithful subjects has been "The Health of Her Majesty the Queen" (cheers), and I am happy to think that upon no occasion and in no year can that toast have been more appropriate than it is on the occasion which brings us here to-night to celebrate the Jubilee of perhaps the greatest scientific discovery in its applied form that has ever, as yet come to improve the lot of man (applause); and it is a happy coincidence that the Jubilee of the Telegraph so closely coincides with that of the best of Sovereigns (cheers). During the fifty years which have elapsed since Her Majesty Queen Victoria ascended the throne of this realm we have come to associate her so closely with that triumphant march of progress and, on the whole, of peace which has distinguished that long period that we sometimes run almost some risk of ceasing to appreciate, as we ought to do, her own individual merits and virtues as a woman and as a Sovereign (applause); but I feel that the events of this past year have brought so largely into view the personal aspect of English royalty, that it is with renewed energy and, if possible, with redoubled loyalty that I beg you to drink "The Health of Her Majesty the Queen."

The toast was honoured with the greatest enthusiasm, the entire company afterwards joining in the singing of the National Anthem.

The CHAIRMAN: Gentlemen—There is a somewhat graceless proverb that tells us that there is nothing sacred to an engineer. I venture to believe that that is a misrepresentation of a body of men who at least know how to reverence all that is deserving of respect (applause), and I wish before we proceed to any other of the toasts upon our list to ask you to join in an expression of reverence for those great and illustrious men, many of whom have ceased to be among us, but some of whom I hope still survive, and I ask you to drink in solemn silence as a mark of respect and reverence "To the Memory of the Pioneers of Telegraphy."

The toast having been duly honoured,

The CHAIRMAN said: Gentlemen—It now falls to me to propose to you the toast of the evening, and I may, I think, well say that no one ever approached a task of great interest and great magnitude with a fuller sense of his own unworthiness to discharge it. I see before me the men who have done so much to extend and to popularise the progress of science, and I must ask you to be tolerant if, in the few observations which I shall venture to address to you, I show how little the labours and engagements of political life enable one to follow that great march of scientific progress whose Jubilee, and especially of the walk of science, we are celebrating here to-night, and I feel this, perhaps, all the more because I am conscious that among my predecessors in the office which I now hold there is at least one man present whose name is a household word wherever science is known and venerated, and who would be infinitely more competent to discharge the duty which has fallen upon me. But as you will have the privilege of listening to Sir Lyon Playfair when he proposes another toast I will venture without further apology to commend to you to the best of my power the toast which forms the subject of our gathering here to-night. Gentlemen, you are all aware that last Monday was the fiftieth anniversary of the first occasion on which the electric telegraph was brought into operation in England (applause), and we have most of us, perhaps, read of that tumultuous sensation which the great Wheatstone confesses to have experienced

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DINNER IN CELEBRATION OF THE JUBILEE OF THE ELECTRIC TELEGRAPH

PLAN OF TABLES.

Mr. H. Alabaster.	Capt. Fonseca Varz	Mr. S. W. Silver	Dr. J. H. Gladstone, F.R.S.	Mr. C. B. Bruce, Pres. Inst. C.E.	The Marquis of Tweeddale	Mr. W. Crookes, F.R.S., Pres. Chem. Soc.	Mr. Edward Graves	Prof. W. G. Adams, F.R.S.	M. Cael	Mr. J. Brett	Mr. H. Weaver	Mr. John Pender	Mr. C. H. B. Patey, C.B.	Mr. G. Shaw-Lefevre, M.P.	Lord Onslow	THE POSTMASTER-GENERAL	Prof. G. G. Stokes, F.R.S. Pres. R.S.	Sir Lyon Playfair, M.P., F.R.S.	Sir W. Thomson, F.R.S.	—	Sir Frederick Goldsmid	Sir Frederick Abel, C.B., F.R.S.	Sir Douglas Galton, F.R.S., Chairman S.A.	Mr. J. S. Macdonald	Mr. Edwin Clark	Sir David Salomons	Sir George Elliott	Colonel Andrews, R.A.	Mr. Matthew Gray	Sir James Anderson	Mr. Norman Lockyer, F.R.S.	Mr. H. W. Bigge.
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	Mr. R. Kaye Gray	Mr. W. J. Tyler	Mr. R. Hunter	Mr. W. Andrews	Mr. E. Bright	Col. R. Jackson *Standard*		*Times*	Mr. J. T. Johnson	Mr. G. L. Bristow	Mr. C. W. Strong, C.B.	Count Reichenbach	Hon. Hy. Marsham	Mr. W. Ford																	
	Mr. J. H. Greener	Mr. H. G. Erichsen	Mr. C. Curtoys	Mr. S. W. Casserley	Mr. J. S. Sellon	Capt. C. McEvoy *Daily News*		*Morning Post*	Mr. D. Davies	Mr. G. Sutton	Mr. J. R. France	Mr. H. F. W. Lewis	Mr. O. Moll	Capt. R. C. Halpin																	
	Mr. A. Bell	Mr. D. J. Dunlop	Mons. Cody	Mr. H. Swan	Mr. H. D. Wilkinson	Mr. W. T. Glover *Electrician*		*Electrical Review*	Mr. H. Borns	Mr. J. Taylor	Mr. F. W. Cooke	Mr. W. Leonard	Mr. E. Dickens	Mr. C. Gerhardi																	
	Mr. D. Lumsden	Mr. W. R. Culley	Mr. W. H. Snell	Mr. A. T. Snell	Mr. W. L. Preece	Mr. A. A. C. Swinton	*Central News*	*Press Association*	Mr. A. S. Betts	Mr. R. S. Hampson	Mr. C. W. Lundy	Mr. H. Marsh	Mr. B. Smith	Mr. T. A. Bullock																	
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Mr. H. C. Fischer — Prof D. E. Hughes, F.R.S. — Mr. W. H. Preece, F.R.S. — Sir Charles T. Bright — Maj.-Gen. C. E. Webber, C.B. (ret.), R.E. — Mr. C. E. Spagnoletti — Mr. Latimer Clark

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when the message which he sent on that little journey from Euston-square to Camden Town was sent back to him by Mr. Cooke (cheers). I am, perhaps, not exaggerating the importance of the occasion when I venture to say that that evening as Wheatstone sat in the small cupboard of an office, communicating with his colleague at a distance of some two miles, was one of the great epochs in the history of human progress (loud cheers); and if ever a spirit of prophecy has filled a man with something of a Divine enthusiasm it may well be that the man with whose name the system of the electric telegraph must ever be inseparably connected may have felt his heart throb with something almost of the supernatural when he realised that the great work had been achieved, that the demonstration had been reached, and that the future of the science had been assured (cheers). If he could have looked forward to those circumstances which are to us part of our everyday lives, he may well have been excused for such a shock to the nerves as hardly any seer of old can ever have encountered in peering into the dark future (applause). I venture to believe when we look back upon the progress of those fifty years we shall find in them the materials of a greater hope of the future of humanity than in almost any other record of any other period in the history of our race. I would remind you that the instrument which was employed by Wheatstone and Cooke displayed five needles, and that it was from the movements and combinations of those five needles that the whole of the alphabet was made up. Those five needles, we are told, were united by means of five copper wires laid in a groove in a triangular block of wood, and I am sure you will be interested to know that a piece of that block is in my hand at the present time (cheers), and well deserves to be preserved among the archives of science. Well, of course we are, with the experience of this half century, well aware that this system in the first instance was crude and imperfect. Demonstration had been arrived at, but perfection had to be reached. The difficulty that was immediately encountered in popularising the system was obviated by the development of the railway enterprise of this country, and the necessity which arose for rapid and certain communication along our lines of railway. And those of us who are in the habit of travelling by the different great lines of the kingdom may, I think, for a moment indulge themselves in the idea of what railway travelling would be if there was no electric telegraph (laughter and cheers). However, some time elapsed before the real development of telegraphy in this country began. The London and Blackwall Railway was, I believe, the first to utilise the system in a practical way. In 1844 the Government of Sir Robert Peel first conceived the idea of utilising the telegraph for other than railway purposes—at least, they were the first to realise how far it could be applied to the service of the State, and that year saw the establishment of a telegraph line, from Waterloo to Gosport, of four wires, of which two were to be utilised by the railway company and two by the Government, and that I think you may say constituted the first public recognition of the value of the electric telegraph (applause). In 1846 the first telegraph company was formed, the Electric Telegraph Company (cheers). In 1850 the first attempt was made to lay a submarine telegraph cable (cheers). A gutta percha wire without any metallic covering was laid between Dover and Calais in August of that year, and you will be interested to know that I have also here a portion of that cable, which was fished up by a ship in the Channel so recently as the year 1875. I am told that the first concessionaire of that cable is present here this evening (cheers). In 1851 a cable was laid in substitution of this gutta-percha cable, which was protected by iron wires and which was the commencement of a regular system of inter-communication between England and the Continent, and this cable, I believe, I am not wrong in associating with the name of one of those gentlemen who is happily still spared to be among us, and to whom I referred just now in connection with the last toast, I mean Mr. Crampton (cheers), and it must indeed be a great satisfaction to anyone who has been connected with great works of this sort to have lived, as Mr. Crampton has done, to witness their enormous development in the service of mankind. The first Atlantic cable was laid in 1858, and other companies arose during those years to compete with the first electric telegraph company, and multiplied throughout the length and breadth of England the agency of the telegraph. In 1870 the multiplication of the companies had become so great, and their competition, though in some respects advantageous to the public, was yet so imperfectly regulated by State requirements that the Government of the day determined to acquire the whole of their enterprises, and to place the telegraphs of the kingdom under the direction of the Post Office (cheers). Now, I should like to say one or two words with regard to the instruments of telegraphy. We are aware—and anyone who wishes for ocular inspection may satisfy himself—that the first telegraphic apparatus employed by Wheatstone and Cooke was one which required five wires through which to transmit their message. It was found gradually that two wires would suffice to forward a message, and after that the progress of science enabled the operators to depend upon one. But after a time it became ascertained that a wire could be used for sending messages in two directions, and after that time four messages came to be transmitted on a single wire, two in either direction, and, as I daresay most gentlemen who are present to-night are aware, at the present time a single wire is being used at the central telegraph station in such a manner as to admit of six messages being sent in one direction, or one in one direction and five in the other, or any other combination of six messages (cheers), and I think that those who perfected these wonderful operations may be thankful that they live in the reign of our present good Queen (cheers), because I am perfectly satisfied that if they had lived in the reign of good Queen Bess most of those gentlemen would have expiated their scientific offences by being burned at the stake (loud laughter). The first instrument was succeeded by the double needle, the double needle by the single needle, and all those systems were visual. Then came in the system of printing on a bit of paper. At first the signs representing the letters were embossed on a band. This was further improved by Prof. Hughes's printing instrument (cheers), by which the actual letters were printed in ink. Then came yet another, probably even more astounding development—the sounder instruments, by which messages are transmitted by sound without any record (applause). I venture to believe that that achievement has outstripped the wildest dreams of imagination. With regard to speed, that I think is also an interesting point. When the first electric telegraph was established the speed of transmission was from four to five words a minute on the five-needle instruments. In 1849 the average rate of transmission of a certain number of messages addressed to *The Times* newspaper was seventeen words a minute. The present pace of the electric telegraph between London and Dublin, where the Wheatstone automatic instrument is employed, amounts to 462 words a minute (cheers), and thus what was regarded as miraculous 50 years ago has multiplied a hundredfold in the course of half a century. Now, you may perhaps like to know, though it is rather descending from the higher walk of this great subject, the number of telegrams which were sent through the Post Office in the United Kingdom last year. The number was 51,500,000 (cheers)—that is to say 1,000,000 per week—and that number is steadily increasing; 41,000,000, or rather more than that number of these were inland messages, and of course a very great proportion of them were press messages I think you should realise the immense boon which the electric telegraph has bestowed upon the press. I gather from such information as I have been able to obtain that the rate of press messages, which, as everybody is aware, is very much less than the rates for other messages, is on the average not much more than 2d. per 100 words; and it is owing to these extraordinary facilities which are afforded by the Post Office to the transmission of press news that the whole of the United Kingdom is put in possession at its breakfast table every morning of everything which it is necessary or important for anybody to know, as well as of a great many things which are neither necessary nor important (laughter and cheers). I believe that I am not wrong in saying that the cost to the public revenue of this reduced rate to the press is not less than £200,000 a year, and that the newspapers of this country

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practically receive a subsidy of £200,000 a year in order to enable them to assist in the diffusion of intelligence (applause). I imagine that the country is also satisfied that this should be so, and that there are very few people who would wish to abridge that privilege having regard to the enormous importance to all classes of the community of being placed at the earliest moment in possession of the fullest knowledge of what is going on (applause). But it is a fact that, owing to the recent reduction in the tariff of telegrams, the value of the telegram, on the average, to the State is now only 8d., whereas two years ago it was 1s. 1d., and before the State took over the telegraphs it amounted to as much as 2s. 2d. I think you may measure something of the enormous gain which the public has achieved by the acquisition by the State of the telegraph system when you look at these figures and reflect that the average price of a telegram at the present time is only about one-third of what it was only seventeen years ago (applause). I am saying this as if I were one of the public; but as Postmaster-General you must be aware that I have to regard this result with somewhat mixed feelings (laughter), and I am endeavouring, as far as I can, to denude myself of any official prepossession in putting before you from the popular side the advantages which you have obtained by the State employment of the telegraphs. But, gentlemen, I feel that I have already trespassed on your patience. I would only say that if you would wish to obtain further knowledge of this most interesting subject, put in the most terse and pregnant way, you cannot do better than study a paper communicated to the Society of Arts by my friend Mr. Preece (cheers), in which the details of this marvellous progress are set out concisely and perspicuously. But I do not like to sit down without reminding you that whereas a Jubilee is generally a time of retrospect—and, indeed, we have a retrospect which I have endeavoured to trace upon which we may look with more than pride and more than satisfaction—yet this moment of retrospect is only one of those in which a powerful and vigorous organisation draws its breath in order to enter upon a new career (loud cheers). Not only have we something to be proud of in the past, but I believe we shall have much more to be proud of in the future. This great agency, which seems to form the vital principle of this planet upon which we live, which has not only gone so far towards annihilating space, but which seems at the present time to be generating light and revolutionising motion, has all the future before it (cheers). Those who are enrolled in its service are probably the disciples of a new and absolutely beneficial dispensation, and with them rests the future in no small degree of the human race (applause), and the means of linking not merely ourselves to our distant colonies—and my noble friend who is beside me (Lord Onslow) reminds me how important is the connection between England and the younger Englands beyond the sea (cheers)—but by going forward in connecting the various races of mankind, by binding island to island and continent to continent, the telegraph is doing in its quiet, noiseless, and in its own unobtrusive way more than all the noisiest missionaries of peace and universal brotherhood have ever accomplished (applause). The names which I ask leave to couple with this toast are those of Mr. Edwin Clark, who is, as we know, one of the veterans in the service of the electric telegraph, and of Mr. John Pender (cheers), who has made our English science cosmopolitan, and last, but certainly not least, the name of Sir William Thomson (prolonged cheers), who, I am proud to think, as a humble member of the same university, has done more than any other person connected with that ancient seat of learning and science to maintain its high reputation as one of the pioneers of scientific thought. Gentlemen, with these three illustrious names I beg to couple this toast, and while thanking you for the patience with which you have listened to what I have ventured to say to you, I make bold to predict for this great science, in whose honour we are gathered together here to-night, another and much ampler Jubilee whenever the next half century enables it to take stock of the marvellous labours which it achieved for the benefit of the human race, for the development of human enlightenment, and for the propagation of universal peace (loud cheers).

The toast was enthusiastically drunk.

Mr. Edwin Clark, who was applauded on rising, in the course of his remarks (which were uttered in so low a tone that they were heard with extreme difficulty, and at times were totally inaudible) said he had been selected for the honour of responding for the past of telegraphy, but he should confine himself to allusions to that which came under his own observation whilst he was connected with the Electric Telegraph Company. The arts and sciences had always been very closely associated, and it was often difficult to say where the one ended and the other began. This was exemplified in the case of telegraphy, which began as a pure science, but had eventually become almost completely an art. Now, however, it was becoming a science again under the fostering care of the clever and energetic men who were engaged in combining theory with practice. Having referred to the fact that Cooke and Wheatstone were the originators of anything like practical telegraphy on a large scale, Mr. Clark said it was he who introduced Wheatstone to Robert Stephenson. Stephenson at once took up the subject of telegraphy, foreseeing its value and importance. He granted permission for the line which had been erected for experimental purposes between Euston and Camden Town to remain. The first use of the telegraph of any importance was made upon this line. There had been previous telegraphing, of course, and he was not saying that Wheatstone invented the telegraph; he was only stating that this was undoubtedly the beginning of the practical application of the telegraph. Mr. Stephenson having taken the matter up, for some years worked very assiduously for its development. In 1837, he (Mr. Clark) believed, he formed a company, which came out as the Electric Telegraph Company. He was associated with some very eminent men—with Whitworth, of Manchester, Ricardo, and others; they were capitalists, and they found the money and formed the Electric Telegraph Company in that way. In the years 1846-7-8 he (the speaker) was employed in the construction of the Britannia Bridge, and had nothing to do with the telegraph, but before he completed the bridge he was sent for to come to town in order that he might take charge of the Electric Telegraph Company, which was then working under very peculiar circumstances. He was told that the expenditure was very large, and that they were losing a sum of something like £50 or £60 a week. His instructions were to go into the matter carefully, and investigate the affairs of the Company, and see whether it would be better to reorganise it or to abandon the undertaking altogether. He knew very little indeed of the subject, for he was not an electrician. But the question which was brought to him for solution was this—there was a certain number of lines, a certain number of customers, and there were certain expenses; could these be modified and so apportioned that the undertaking could be made to pay its way? When he and his brother (who was associated with him in the inquiry) came to look into the affair, they found that very great economy could be effected in different ways. There was a great deal too much laboratory work going on at that time; there was nothing decided or known, no uniformity, the wires were of all sorts and sizes, and the materials generally were in a very precarious condition. The first thing was to get the instruments into proper workmanlike form, and to secure the proper insulation of the wires. The poles on which the line was suspended were of a very light character, were too small, in fact, and he brought down a number of excellent practical men from the Britannia Bridge to overhaul the whole concern. About this time he (the speaker) was engaged in negotiating with the whole of the railways with the idea of thoroughly working out the telegraph system. They were treated by the railway companies with very great liberality. They gave them rights of way, and even paid a portion of the expenses of laying the Telegraph Company's lines. They found it so important to themselves that it was worth their while to give it their assistance, and there was such a demand for the telegraph they could hardly execute the work fast enough. They laid down, generally speaking, a special line for the railway companies, and a special line for themselves, it being understood that they assisted each other with their respective wires. They had a clerk in almost the whole of the stations, who was partly paid by the railway companies, and partly by the Electric Telegraph Company, and whose duty it was to transmit the messages of the companies. That was the

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beginning of the commercial success of the undertaking, and it was entirely attributable to the railway companies. About this time he was deputed by the North-Western Railway Company to examine the telegraph systems of Europe, and especially of Germany. From what he saw during that journey he recommended the adoption of a system which had now come into almost universal use, the block system (applause). Their instruments and their wires were at that time of a very elementary character, and they very seldom tested the lines for the reason that their testing instruments were not at all applicable for the purposes of durable telegraphy. But these matters were soon improved under the supervision of the excellent staff he had around him. There were associated with him Varley, his (the speaker's) brother and Mr. Preece (the latter of whom he was glad to have introduced to the service). These and others turned their attention to the improvement of the apparatus, and so many alterations were made that in a short time the company was placed on a good sound footing. Having briefly referred to the earlier investigations in regard to telegraphy, Mr. Clark concluded by referring to the work done in connection with submarine telegraphy by Mr. Jacob Brett, who was present at that gathering, but since whose first attempts were made wonderful progress had taken place (cheers).

Mr. JOHN PENDER, who on rising to respond on behalf of telegraphy in the present was loudly cheered, said: Mr. Raikes, my Lords and Gentlemen—You have heard to-night the very admirable speech of our president, and he has given you in a very concise form the progress of telegraphy during the last fifty years. He has told you of the little telegram from Euston to Camden Town, and of the anxieties which attended those first moments of the telegraph; and he has also told you that to-day there are over 50 millions of telegrams passing over the telegraph lines of this country. I have been asked to speak of the present of the telegraph. In these few words I tell you what land line telegraphy is and what it has achieved. My mission to-night is more to tell you what submarine telegraphy has done (applause.) Let it be remarked first that I do not speak as an electrician. I believe I am correct in saying that the majority of this company are electricians, but I am one of those few commercial men who at an early period of telegraphy saw that there was in it the promise of a beneficent instrument for the future progress of the world. I have gone into submarine telegraphy, not as an expert, but as one of those who have come forward and taken Science by the hand, and led it up to the glorious results which we have seen. Twenty years ago there were only something like 2,000 miles of submarine cables; now there are 115,000 miles, and it has cost something like £38,000,000 or £39,000,000 sterling to put that amount of telegraph cable to the bottom of the sea. There was a prophecy long ago that the earth was to be girded round in forty minutes. Why, we have got as much submarine telegraph cable as will go round the world five times, and we can send a message round the world in twenty minutes at the present moment. You ask me where does all this submarine telegraphy extend, and I would reply in those beautiful lines of the poet—

> "Far as the breeze can bear the billows' foam,
> Survey our Empire and behold our home!"

Wherever the British ship goes, or the British flag flies, there we have set the submarine telegraph, and at the present moment while I am speaking to you human thought is travelling like lightning to every part of the world. The future of that no man can tell. Of the 100,000,000 words which are now carried by submarine telegraphy nine-tenths are for commercial purposes. You can conceive the amount of progress and the amount of benefit to the human race which follow the facilities thus given to commerce. I might talk for a long period of the advantages which telegraphy has given to politics, to commerce, and to social interest; but I will only say this, that if the progress of the next fifty years is as great as the progress of the last twenty it will be the greatest marvel that has ever been known in this world (applause). I know the value of time, gentlemen; I have been taught that in telegraphy. I know there are many much more important speeches to follow, and therefore I will not detain you longer than this. When the history of these fifty years of Her Majesty's glorious reign is written telegraphy, and more especially submarine telegraphy, will be shown to have done more than anything else to federate the great colonies and the mother country, to spread civilisation throughout the world, and to make this great world of ours as near as possible one common country (cheers).

Sir WILLIAM THOMSON then rose to respond, and was greeted with an enthusiastic outburst of cheering. He said: Mr. Raikes, my Lords, and Gentlemen—It is with feelings of a very mixed character that I appear this evening to speak for my fellow workers in the great work of the last thirty years of ocean telegraphy. I understand that it is ocean telegraphy in respect of which you have done me the honour of allowing me to speak this evening, because in the earlier part of the development of the telegraph I had no part; I have only recollection. But I do feel that when the telegraph has been so important a bond for all the nations of the world that we ought to go even beyond our fifty years' Jubilee and think for a moment of the great names from other countries to whom the possibility of the Jubilee of the Electric Telegraph has been due—the great apostles of electrical science in France, Coulomb and Ampère (cheers). Ampère, whose work and whose discoveries constitute the foundation of the most important of modern telegraphic and electric instruments generally—Ampère, whose name has become Anglicised and is invariably used in measuring the currents which produce the electric light. Then Gauss and Weber, who made the first electric telegraph. Mr. Edwin Clark justly and fairly expressed himself just now when he said that the telegraph of Cooke and Wheatstone was the first practical working telegraph, but he knew that others had worked in that field before, and that it was the practical realisation of their work that we owe to our own great countrymen, of whose splendid works he has spoken so ably. The telegraph of Gauss and Weber, and the Munich telegraph of Steinheil, and the Steinheil key, which is the manipulating telegraph key of the present day—these were the elements of telegraphy. We justly rejoice that in England so much was made of the work of those grand pioneers in science. In America the race of practical work commenced almost simultaneously with our own in the splendid telegraph of Morse. In speaking of the telegraph we almost forget time and space, and I must go back to the previous work of Henry, who anticipated in some points some of the finest discoveries of Faraday, and laid a large part of the theory of current induction, which is at the very root of some of the most splendid realisations of modern electrical science, not merely for the electric telegraph, but for electric lighting. But I am reminded that my own position to-night is to speak of my fellow workers in ocean telegraphy, and in doing so I may say I have very mixed feelings. Most of them have gone away, few are here now, I am almost alone. By the work of 1857—a few years before the half of the Jubilee—the two brothers Edward and Charles Bright and Whitehouse—those three men, with Mr. Cyrus Field, had reduced to practice the brilliant dream of Cyrus Field to connect England and America by means of submarine telegraphy. Then there were the brothers Werner and William Siemens working in the same direction, and the great navigator Moriarty, who was out in the "Agamemnon" in 1857. I had the honour of being shipmates with him on the "Agamemnon." He navigated the "Agamemnon" in 1858. I was on the "Great Eastern," with Sir James Anderson as navigator. In 1865 and 1868 he picked up the cable, and again in 1866—in 1865, when it was broken, and in 1866, coming back a year after, in the same place, hitting upon it just a quarter of a mile away by splendid navigational powers. Canning and Clifford, Varley and Jenkin (who was my special partner), and who worked altogether for many years. I, alone, am here to speak for the three. Willoughby Smith, who did such fine work in 1865-6 in testing the cable, applying the newest developments of science, many of them his own inventions, to do what had never been done before, to test a submarine cable with the delicacy that was necessary under cir-

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THE TELEGRAPH JUBILEE BANQUET.

Although the Jubilee Banquet in commemoration of the Fiftieth Anniversary of the ELECTRIC TELEGRAPH was presided over, as fittingly it should be, by the English Postmaster-General, the assembled guests were sufficiently representative and imperial to raise the event far above the level of a mere official or insular festivity. English citizens, however, as distinct from any English Government, have special cause for pride and congratulation on an occasion like the present. The ELECTRIC TELEGRAPH may be claimed, without much presumption, as their own invention; and as a working system it may be said to be almost literally their personal property. Still more flattering is the fact that in its broader and mightier aspects the ELECTRIC TELEGRAPH is the work of their unaided genius and indomitable perseverance. Other nations have their local telegraphs just as England has hers; but no people or nation can rob her sons of the distinction of having linked together in these days the widely separated families of the world, and put them on speaking terms with each other as brothers with brothers.

This is no mean achievement, and its greatness was fully appreciated by every speaker, conspicuously by the Chairman himself, who addressed the distinguished and historic gathering of telegraphic, engineering, and scientific representatives on Wednesday night. For, assuredly, the essential boon which mankind owes to the discovery of electric telegraphy is not to be seen in its adaptation to local and domestic uses, great indeed as these are, but in its application to the intercourse of nations one with another; and in the gradual effacement of those hostile barriers which are the natural consequence of ages of estrangement. We are not reckoning on the millenium; and we do not imagine that the ELECTRIC TELEGRAPH is going to insure universal peace and goodwill by its own unassisted magic. But we may humbly affirm that there is no single agency at present wielded by man that is tending so much towards that end, or that with such reasonable confidence may be predicted to bring it about in due time.

Of its material benefits we need not speak at any great length here, but it naturally suggested many eloquent eulogiums in the after dinner speeches. By increasing the agencies and facilities of commerce, the TELEGRAPH has enormously enlarged the productiveness of the earth, and widened the scope of human industry upon every corner of it. And it necessarily follows that as nations and peoples become more and more dependent on each other's well-being for the necessaries and luxuries of life which, but for the TELEGRAPH, could never be supplied, the more likely are they to forget their race prejudices, and to let their animosities be swallowed up in their material and social interests.

All this is certainly true of the nations remotely apart. Of those nearer together it is sometimes said that their quarrels are fomented by electricity, and that telegraphy is responsible for keeping the European families at fever heat. Probably the truth is that the telegraph is far less to blame than the incendiaries who abuse it for their own selfish aims. At any rate it may be urged on the other side that if the electric message is quick to provoke it is not less swift to appease. Many instances might be cited of the telegraph playing the part of peacemaker when nothing but its instrumentality could have averted a pitiless war. All wars, it has been truly said, are the result of misunderstanding; and for prompt agreement with "thine adversary" there is nothing to equal the telegraph.

On these higher functions of the ELECTRIC TELEGRAPH we dwell with hopefulness and pride to-day. Those narrow minded reformers who magnify what may be called the parochial advantages of the telegraph, to the disparagement, or at all events the neglect of, its cosmopolitan services, might learn a useful lesson from the speeches of the men whose foresight and energy have established telegraphy over every part of the habitable globe. Their conception of the telegraph's mission was, and is, a far loftier one. But, taking merely insular and patriotic grounds, it is clear that the British Empire has most to gain by enterprises of this kind; and that her international and intercolonial cable systems are of the deepest national concern to us. Compared with the security, the efficiency, and the financial prosperity of these lines, the welfare of our inland telegraph system is an insignificant matter indeed. Only when the distances to be traversed are considerable, and when the interests involved are momentous, is the true value of the telegraph impressed upon us. Within narrower limits it may be misused, or abused, or even dispensed with like any other luxury. But long distance telegraphy over lands and seas has become an indispensable instrument of England's preponderance as an imperial and mercantile power. Twenty years of submarine telegraphy, as was truly said on Wednesday night, have done more to make this nation rich and prosperous, more to make her

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people well fed and well clad, than all the political nostrums which parliamentary ingenuity has concocted during a century. The JUBILEE of the ELECTRIC TELEGRAPH will not have been celebrated in vain if only this important fact is impressed upon the public mind, and upon the minds of statesmen into whose hands are committed the destinies of this great empire.

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cumstances so peculiar, so utterly new. I am exceedingly sorry he is not with us this evening. I hope we shall see him many times more, upon some such occasions as this, and that he will soon recover from his temporary illness. But I can never forget that we scientists alone could not have done what has been done. I well remember the dead period of eight years, the middle of which was just the middle of our Jubilee that we are celebrating to-night—the years from 1857 to 1866. We were on our backs; we could do nothing in science; the cable had been laid—it proved to be a success; it had delivered messages—a message passed from the President of the United States to Her Majesty the Queen, and was answered by a gracious message from the Queen, and an important message countermanded the return of two regiments from Canada to England in order to go to India to quell the Mutiny—the countermanding of the return from Canada was done by the Atlantic cable of 1858. The Mutiny had happily come to an end, their presence at the end of the diameter of the earth, or pretty nearly so, was not needed, and the Atlantic cable of 1858 conveyed the intelligence to them that they might remain in Canada. The cable failed. I do not remember at present how much money was spent upon it—half a million, I believe—and science could do no more. To two men, I believe, is due the existence of the 1865 cable, and all the consequences that followed from the 1865 66 cable—John Pender and Cyrus Field (applause). With American spring, life, and energy Cyrus Field flashed across the Atlantic, not by wire, though, to our slow minds, it almost seemed so. He was here trying to get up an undertaking somehow or other, trying to induce English capitalists and scientific men to join together. But one man, Mr. Pender, was steadfast to the work. He was a director in 1858 of the Atlantic Telegraph Company. He, with some of his colleagues, remained on, and with Cyrus Field persevered until the successful undertaking of 1865. I call it successful, because it was really a successful undertaking, although the cable was only half laid. It led, with further tremendous effort and self-sacrifice on the part of those devoted men, and others who joined them, to the great and enduring success of 1866. But I am asked to speak of the present time of telegraphy, and not merely of submarine telegraphy, and I must remember that there are other things besides ocean telegraphs. We have our land telegraphs, of which you, Sir, have spoken. You have told us how splendidly the land telegraphs are worked, you have pointed out how admirably, under the influence of the Government system, the application of science to telegraphy has been developed. I think you may feel proud, Sir, in knowing that under Government management within these last seventeen years the applications of science to telegraphy have not stood still, but, on the contrary, have been pushed forward with every possible energy, and with the most marvellous success (applause). You have told us that the rate of working between Dublin and London has reached 460 words per minute, I think we may say 500 words per minute, and that is ten times what it was ten years ago. That is something for a Government Department to be proud of; and, for a Government, I must say there is some little political importance in the fact that Dublin can now communicate its requests, its complaints, and its gratitudes (laughter) to London at the rate of 500 words per minute. It seems to me an ample demonstration of the utter scientific absurdity of any sentimental need for a separate Parliament in Ireland (laughter and applause). I should have failed in my duty in speaking for science if I had omitted to point out this, which seems to me a great contribution of science to the political welfare of the world (applause).

The Right Hon. Sir LYON PLAYFAIR, M.P., who was loudly cheered, said: Mr. Raikes, my Lords, and Gentlemen—The toast which I have been asked to propose to you is that of "The Scientific Societies." I am sure that is a toast which you will all welcome here. There is some difference between the societies of the country and the peculiar habitudes of my friend who has just spoken. He is a remarkable example of a man from whom science and invention come from every alternate pore of his body. He is sometimes scientific, he is sometimes inventive; but the scientific societies do not profess invention. They profess to lay down the laws of science and to advance natural knowledge; and men who have contributed to advance natural knowledge like Œrsted, Faraday, Ampère, and others, are as much the discoverers of the electric telegraph as if they had themselves actually aided in the invention; because the duty of the scientific societies is to cultivate the tree of knowledge (applause). The tree of knowledge is one of slow growth, but in its time it produces the fruit of industrial invention. Those industrial inventions often—generally do—come by slow degrees, and it is very difficult often to say who is the first and true inventor of any particular contribution to industry. It is very rare—indeed, it is never the case—that a great invention which changes the face of society comes suddenly to the world, as Minerva came out of the brain of Jupiter, panoplied and full armoured. But recollect that even Jupiter could not do this till he swallowed the mother of Minerva, Metis, in the first month of her gestation, and then the gestation took a prodigious time, and afterwards there was a remarkable demonstration of Minerva coming out panoplied and full armoured. Now this is what inventors do. After science has gone through a proper process of gestation in their bodies, then come out their inventions slowly and by degrees, so much so that even in the case of a great invention like the steam engine, which is the only thing comparable with the electric telegraph in the influence it has had on the progress of the world, one of the highest courts of justice in this realm has decided, after reviewing all the steps in the advancement of the steam engine, that Watt contributed nothing at all towards it (laughter). It is the same with regard to telegraphy. One does not know when the electric telegraph was first invented. There was one little incident that I may mention. Many years ago I was dining at the mess of the Artillery, at Woolwich, and Prof. Wheatstone was one of the guests. I forget what the toast was, but it was something connected with his discoveries in electricity, and I described him in my speech as the discoverer of the electric telegraph. At that time Wheatstone and I lived within a few doors of each other, he on one side of Hampstead Bridge and I immediately at the other, and we always went home together, and he censured me for my foolish speech. He said that he was not the discoverer of the electric telegraph—that Œrsted and Faraday were its true discoverers, for it was from their discoveries that electric telegraphy originated. He had admitted that there had been many experiments in telegraphy before his day, but he claimed with pride that he had done considerable things for the practical promotion of telegraphy, and for the instruments which he invented in order to promote them. Now, the scientific societies to which I ask you to drink have for their duty the advancement of natural knowledge. Wheatstone himself was more proud in advancing natural knowledge than he was in the advancement of telegraphy, because he knew that it was by laying the foundation of science on a sound and firm basis that we are able to make inventions and applications of that science which does so much for humanity (applause). It is natural that we are struck in telegraphy with the almost practical annihilation of time and space. That strikes our imagination, but what telegraphy has done for the world is incalculable not only in adding largely to the resources of Government, but in having profoundly changed the whole practice of commerce all over the world (hear, hear). Capital which was formerly used in one way has now to find completely different outlets for its utility. The system of exchange

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THE TELEGRAPH JUBILEE BANQUET.

Although the Jubilee Banquet in commemoration of the Fiftieth Anniversary of the ELECTRIC TELEGRAPH was presided over, as fittingly it should be, by the English Postmaster-General, the assembled guests were sufficiently representative and imperial to raise the event far above the level of a mere official or insular festivity. English citizens, however, as distinct from any English Government, have special cause for pride and congratulation on an occasion like the present. The ELECTRIC TELEGRAPH may be claimed, without much presumption, as their own invention; and as a working system it may be said to be almost literally their personal property. Still more flattering is the fact that in its broader and mightier aspects the ELECTRIC TELEGRAPH is the work of their unaided genius and indomitable perseverance. Other nations have their local telegraphs just as England has hers; but no people or nation can rob her sons of the distinction of having linked together in these days the widely separated families of the world, and put them on speaking terms with each other as brothers with brothers.

This is no mean achievement, and its greatness was fully appreciated by every speaker, conspicuously by the Chairman himself, who addressed the distinguished and historic gathering of telegraphic, engineering, and scientific representatives on Wednesday night. For, assuredly, the essential boon which mankind owes to the discovery of electric telegraphy is not to be seen in its adaptation to local and domestic uses, great indeed as these are, but in its application to the intercourse of nations one with another; and in the gradual effacement of those hostile barriers which are the natural consequence of ages of estrangement. We are not reckoning on the millenium; and we do not imagine that the ELECTRIC TELEGRAPH is going to insure universal peace and goodwill by its own unassisted magic. But we may humbly affirm that there is no single agency at present wielded by man that is tending so much towards that end, or that with such reasonable confidence may be predicted to bring it about in due time.

Of its material benefits we need not speak at any great length here, but it naturally suggested many eloquent eulogiums in the after dinner speeches. By increasing the agencies and facilities of commerce, the TELEGRAPH has enormously enlarged the productiveness of the earth, and widened the scope of human industry upon every corner of it. And it necessarily follows that as nations and peoples become more and more dependent on each other's well-being for the necessaries and luxuries of life which, but for the TELEGRAPH, could never be supplied, the more likely are they to forget their race prejudices, and to let their animosities be swallowed up in their material and social interests.

All this is certainly true of the nations remotely apart. Of those nearer together it is sometimes said that their quarrels are fomented by electricity, and that telegraphy is responsible for keeping the European families at fever heat. Probably the truth is that the telegraph is far less to blame than the incendiaries who abuse it for their own selfish aims. At any rate it may be urged on the other side that if the electric message is quick to provoke it is not less swift to appease. Many instances might be cited of the telegraph playing the part of peacemaker when nothing but its instrumentality could have averted a pitiless war. All wars, it has been truly said, are the result of misunderstanding; and for prompt agreement with "thine adversary" there is nothing to equal the telegraph.

On these higher functions of the ELECTRIC TELEGRAPH we dwell with hopefulness and pride to-day. Those narrow minded reformers who magnify what may be called the parochial advantages of the telegraph, to the disparagement, or at all events the neglect of, its cosmopolitan services, might learn a useful lesson from the speeches of the men whose foresight and energy have established telegraphy over every part of the habitable globe. Their conception of the telegraph's mission was, and is, a far loftier one. But, taking merely insular and patriotic grounds, it is clear that the British Empire has most to gain by enterprises of this kind; and that her international and intercolonial cable systems are of the deepest national concern to us. Compared with the security, the efficiency, and the financial prosperity of these lines, the welfare of our inland telegraph system is an insignificant matter indeed. Only when the distances to be traversed are considerable, and when the interests involved are momentous, is the true value of the telegraph impressed upon us. Within narrower limits it may be misused, or abused, or even dispensed with like any other luxury. But long distance telegraphy over lands and seas has become an indispensable instrument of England's preponderance as an imperial and mercantile power. Twenty years of submarine telegraphy, as was truly said on Wednesday night, have done more to make this nation rich and prosperous, more to make her

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people well fed and well clad, than all the political nostrums which parliamentary ingenuity has concocted during a century. The JUBILEE of the ELECTRIC TELEGRAPH will not have been celebrated in vain if only this important fact is impressed upon the public mind, and upon the minds of statesmen into whose hands are committed the destinies of this great empire.

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cumstances so peculiar, so utterly new. I am exceedingly sorry he is not with us this evening. I hope we shall see him many times more, upon some such occasions as this, and that he will soon recover from his temporary illness. But I can never forget that we scientists alone could not have done what has been done. I well remember the dead period of eight years, the middle of which was just the middle of our Jubilee that we are celebrating to-night—the years from 1857 to 1866. We were on our backs; we could do nothing in science; the cable had been laid—it proved to be a success; it had delivered messages—a message passed from the President of the United States to Her Majesty the Queen, and was answered by a gracious message from the Queen, and an important message countermanded the return of two regiments from Canada to England in order to go to India to quell the Mutiny—the countermanding of the return from Canada was done by the Atlantic cable of 1858. The Mutiny had happily come to an end, their presence at the end of the diameter of the earth, or pretty nearly so, was not needed, and the Atlantic cable of 1858 conveyed the intelligence to them that they might remain in Canada. The cable failed. I do not remember at present how much money was spent upon it—half a million, I believe—and science could do no more. To two men, I believe, is due the existence of the 1865 cable, and all the consequences that followed from the 1865 66 cable—John Pender and Cyrus Field (applause). With American spring, life, and energy Cyrus Field flashed across the Atlantic, not by wire, though, to our slow minds, it almost seemed so. He was here trying to get up an undertaking somehow or other, trying to induce English capitalists and scientific men to join together. But one man, Mr. Pender, was steadfast to the work. He was a director in 1858 of the Atlantic Telegraph Company. He, with some of his colleagues, remained on, and with Cyrus Field persevered until the successful undertaking of 1865. I call it successful, because it was really a successful undertaking, although the cable was only half laid. It led, with further tremendous effort and self sacrifice on the part of those devoted men, and others who joined them, to the great and enduring success of 1866. But I am asked to speak of the present time of telegraphy, and not merely of submarine telegraphy, and I must remember that there are other things besides ocean telegraphs. We have our land telegraphs, of which you, Sir, have spoken. You have told us how splendidly the land telegraphs are worked, you have pointed out how admirably, under the influence of the Government system, the application of science to telegraphy has been developed. I think you may feel proud, Sir, in knowing that under Government management within these last seventeen years the applications of science to telegraphy have not stood still, but, on the contrary, have been pushed forward with every possible energy, and with the most marvellous success (applause). You have told us that the rate of working between Dublin and London has reached 460 words per minute, I think we may say 500 words per minute, and that is ten times what it was ten years ago. That is something for a Government Department to be proud of; and, for a Government, I must say there is some little political importance in the fact that Dublin can now communicate its requests, its complaints, and its gratitudes (laughter) to London at the rate of 500 words per minute. It seems to me an ample demonstration of the utter scientific absurdity of any sentimental need for a separate Parliament in Ireland (laughter and applause). I should have failed in my duty in speaking for science if I had omitted to point out this, which seems to me a great contribution of science to the political welfare of the world (applause).

The Right Hon. Sir LYON PLAYFAIR, M.P., who was loudly cheered, said: Mr. Raikes, my Lords, and Gentlemen—The toast which I have been asked to propose to you is that of "The Scientific Societies." I am sure that is a toast which you will all welcome here. There is some difference between the societies of the country and the peculiar habitudes of my friend who has just spoken. He is a remarkable example of a man from whom science and invention come from every alternate pore of his body. He is sometimes scientific, he is sometimes inventive; but the scientific societies do not profess invention. They profess to lay down the laws of science and to advance natural knowledge; and men who have contributed to advance natural knowledge like Œrsted, Faraday, Ampère, and others, are as much the discoverers of the electric telegraph as if they had themselves actually aided in the invention; because the duty of the scientific societies is to cultivate the tree of knowledge (applause). The tree of knowledge is one of slow growth, but in its time it produces the fruit of industrial invention. Those industrial inventions often—generally do—come by slow degrees, and it is very difficult often to say who is the first and true inventor of any particular contribution to industry. It is very rare—indeed, it is never the case—that a great invention which changes the face of society comes suddenly to the world, as Minerva came out of the brain of Jupiter, panoplied and full armoured. But recollect that even Jupiter could not do this till he swallowed the mother of Minerva, Metis, in the first month of her gestation, and then the gestation took a prodigious time, and afterwards there was a remarkable demonstration of Minerva coming out panoplied and full armoured. Now this is what inventors do. After science has gone through a proper process of gestation in their bodies, then come out their inventions slowly and by degrees, so much so that even in the case of a great invention like the steam engine, which is the only thing comparable with the electric telegraph in the influence it has had on the progress of the world, one of the highest courts of justice in this realm has decided, after reviewing all the steps in the advancement of the steam engine, that Watt contributed nothing at all towards it (laughter). It is the same with regard to telegraphy. One does not know when the electric telegraph was first invented. There was one little incident that I may mention. Many years ago I was dining at the mess of the Artillery, at Woolwich, and Prof. Wheatstone was one of the guests. I forget what the toast was, but it was something connected with his discoveries in electricity, and I described him in my speech as the discoverer of the electric telegraph. At that time Wheatstone and I lived within a few doors of each other, he on one side of Hampstead Bridge and I immediately at the other, and we always went home together, and he censured me for my foolish speech. He said that he was not the discoverer of the electric telegraph—that Œrsted and Faraday were its true discoverers, for it was from their discoveries that electric telegraphy originated. He had admitted that there had been many experiments in telegraphy before his day, but he claimed with pride that he had done considerable things for the practical promotion of telegraphy, and for the instruments which he invented in order to promote them. Now, the scientific societies to which I ask you to drink have for their duty the advancement of natural knowledge. Wheatstone himself was more proud in advancing natural knowledge than he was in the advancement of telegraphy, because he knew that it was by laying the foundation of science on a sound and firm basis that we are able to make inventions and applications of that science which does so much for humanity (applause). It is natural that we are struck in telegraphy with the almost practical annihilation of time and space. That strikes our imagination, but what telegraphy has done for the world is incalculable not only in adding largely to the resources of Government, but in having profoundly changed the whole practice of commerce all over the world (hear, hear). Capital which was formerly used in one way has now to find completely different outlets for its utility. The system of exchange

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has been entirely altered, and the sons of merchants of fifty years ago no longer carry on their business by any of the traditions of their fathers. The whole system of commerce and Government has been altered by telegraphy. Now then the lesson—and it is the last thing I want to say—the lesson which telegraphy teaches us is this, that while we should rejoice in inventions we should never forget that science is the mother of invention, and that we should sympathise with every effort to promote the advance of natural knowledge. I am sure it is not necessary here to answer any of those stupid questions which forty or fifty years ago were asked of scientific men. "*Cui bono?* What is the use of your abstract discovery? It has no relation to the utilities of life." You recollect how Faraday answered that by asking another question. When somebody asked him what was the use of some abstract discovery he had made he replied by saying, "What is the use of a baby?" (cheers) But round that baby are all the hopes and all the future aspirations of the parents. It contains the potentiality of good and evil, and even the State interferes on its behalf by bringing in legislation to make it a good and useful citizen. Therefore we should, in regard to all discoveries, however unimportant they seem, do everything to promote their growth and to promote the growth of natural knowledge throughout scientific societies, not only in this country, but all over the world, and therefore I ask you to drink this toast, and I beg to join with it the name of one of the most distinguished scientific men in this kingdom, Prof. Stokes, the President of the Royal Society; and also the name of Dr. Gladstone (cheers).

The toast having been cordially drunk,

Prof. STOKES said: Mr. Raikes, my Lords, and Gentlemen—Considering the nature of the present occasion it might, perhaps, be expected that I should say something of the practical application of scientific studies to the ordinary purposes of life; but I am sure it will be thought unnecessary that I should say anything on that topic. Every electrician present, of whom there are so many, must know that the practical applications of electricity could not be what they are were it not for the investigations of scientific men—of those who perhaps have studied electricity from a purely scientific point of view. Therefore, in the few words with which alone I intend at this late hour of the evening to trouble you, I propose rather to refer to the reciprocal benefit which the study of abstract science has received from the labours of those who have applied science to the wants of life. Scientific men know well how fascinating is the pursuit of science. Some have even gone so far as to consider that it would be polluted, if I may so speak, by being applied practically. An eminent foreign mathematician delighted in the theory of numbers because one could not conceive that it could have any practical application. An eminent English mathematician I heard express a somewhat similar sentiment, and I dare say Sir William Thomson may remember it—there were three of us present on that occasion. All honour be to those who are so immersed, if I may so speak, in abstract science that they disregard and even dislike its application. They pursue science with all the more zest, they pursue it in directions which possibly otherwise it might not have been possible to follow out, and possibly in the end their own investigations may admit applications which they never dreamt of. But for my own part my tastes do not quite lie in that direction. I like to see science connected with applications thereof, no matter to what purpose (hear, hear), and I think that my friend, Sir W. Thomson, has tastes similar to my own in that respect. Now, when we apply abstract science to physical subjects we are not only enabled to investigate natural phenomena in a manner which could not otherwise be done, but the study reacts on the most abstract parts of science and enables us sometimes to see as if it were by intuition truths of of an abstract nature, such as, for example, propositions in pure mathematics, which we, perhaps, should never have arrived at if we had not viewed them through the spectacles, so to speak, of their physical application. But that is not all. When science comes to be applied to the wants of life scientific men are placed by the practical men in the condition of making experiments which oftentimes would otherwise be impossible. When science comes to be applied to commerce it then becomes possible to construct instruments on a scale the expensiveness of which would be utterly prohibitory to the scientific man (applause); but, when these instruments are constructed, it may be for commercial purposes, the scientific man on his part is able by the favour of those who have constructed them, or by those for whom they have been constructed, to make experiments with them, which oftentimes are of great interest from a purely scientific point of view (hear, hear). I remember the interest with which I read some of the experiments which Faraday made by means of a cable which had been constructed for crossing the Atlantic, though as yet it lay in its tank. The theory of this is now well known, and my friend on my left (Sir William Thomson) has been one of the foremost in investigating it; but then the subject was scientifically in its infancy, and I do not know how far or how fast it might have progressed had it not been for the facilities for scientific investigations which have been placed in the hands of pure scientists by those who constructed their instruments for the purposes of commerce and the general objects of life. Gentlemen, at this late hour I will no longer detain you, but thank you for the honour you have done me (cheers).

Dr. GLADSTONE, responding on behalf of the Royal Institution, said he felt it was no small honour to take part in the proceedings of so interesting a gathering. He was sincerely sorry that Sir Frederick Bramwell, who was to have responded to the toast, was unable to be present to delight and instruct them with his genial wit and wisdom. As far as the Royal Institution was concerned, of course it was not the Royal Institution which had been spoken to in the toast, but rather those members connected with it in reference to telegraphy and electrical science. At the Royal Institution there were not merely memories binding them to all those who had passed away, but they had also many relics. They preserved the log books of Davy, Faraday, and others, and not only that, but there were a great number of pieces of wire, sealing wax, and card, all damaged, and many other things which Faraday used to delight to work with, and to carry out the first experiments which were suggested by the ideas that were working in his brain, and these were preserved as germs of some of these great discoveries. They had there, for instance, a small range of soft iron with iron wire twisted round it, insulated by calico, and tied up with string, from which he obtained his first electric effects from magnetism (applause). He mentioned these things because they had already had brought before them in one form and another many ways in which the electric telegraph had been traced back to its original germs, and here he wanted to point out one of those germs connected with telegraphy. Those relics preserved at the Royal Institution were only worth originally a few pence or shillings; how different the monster wealth which had now become the capital of those great enterprises! As far as the Royal Institution was concerned, its connection with the electric telegraph was to a certain extent not direct, and yet it was very real. Sir Humphrey Davy worked there of course largely with galvanic electricity, but he belonged to the pre-telegraphic era. Faraday himself commenced to work early in these matters, and continued to try and image in his own mind what was taking place in these phenomena, and he always marvelled at the results arrived at even when he knew more than anybody else about what took place. He seemed to have been constantly wrapped in his experiments, and his enthusiasm took him forward from discovery to discovery, all tending to show connections between the different branches of electricity and the various forces with which they were acquainted. It had already been remarked by Sir Lyon Playfair that Faraday was a discoverer, and did not care much for invention. There were some, like Wheatstone and Sir William Thomson, who were distinguished in both departments, but it was not given to very many to be so. Faraday gave the whole of his life to investigation and development; but while he did that he also encouraged those who were working in practical applications. It was an important point with him that the glories of science should conduce to the benefit of man. They knew his influence with Sir Charles Wheatstone was very great, and he got him

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into the dark chambers at the Royal Institution, and talked to him about his investigations, and in the theatre brought before him some of those experiments which were afterwards performed with so much success in public. In one way and another Faraday had to do with the industrial applications of electricity as well as with scientific discovery. One of the very earliest experiments of Faraday that led to some of his discoveries was in relation to Ampère's experiments. They had a record of how delighted he was when he found that he was able to produce not only the effect of the wire revolving round the magnet but of the magnet revolving round the wire, and how he revolved round the whole of his experiments and declared he would do no more work on that day (applause). In another reminiscence they found him thinking of what could be taking place in the dielectrics, and getting out what was retarding the force, what was enabling the force to propagate, until at last he conceived the idea of specific inductive capacity. They knew how that was taken up by Sir William Thomson and others in various ways, and led to a number of other interesting discoveries (applause). Those were the trophies of early electrical discovery; but electrical discovery would have been of very little use if it had not been that others came in and took up those discoveries and applied them. They had the combination of the purely scientific man with the practical man, and these two going together with slow, careful, conscientious investigation, followed by the energetic carrying out of the discovery in a form which benefited mankind (applause).

Mr. SHAW-LEFEVRE, M.P., said: Mr. Raikes, my Lords and Gentlemen—I feel highly honoured by being called upon to propose to you the next toast, and I shall best show my appreciation of that honour by ruthlessly cutting down by three-fourths what I had intended to say to you, for at this late hour of the night you are doubtless anxious to get away. I am, gentlemen, I am sorry to say, just old enough to recollect, if not the birth of telegraphy, at all events its earliest infancy, for I have a vivid recollection of having been taken by my father, when a boy, to the house of a friend, where Prof. Wheatstone set up a model of his invention, and where it was explained to us by the two great inventors—namely, Prof. Wheatstone himself and Faraday. It impressed itself on my mind the more because, although I understood very little about it, I recollect my father saying that I had met two great men on that occasion, the authors of an invention the nature of which nobody could then understand. When I was a boy at Eton I recollect well the extension of the telegraph from London to Slough, and of an incident of which you are all aware, the arrest of Towell, which I believe brought the telegraph more into notice than anything at that time. It might have been expected that the authorities at Eton, seeing a great invention of this kind brought to their door, might have been desirous of explaining it to the boys of the school, and might have been drawn out of their deep slumber of ages, and done something for the scientific education of the boys then at Eton. But no thought of that kind ever entered into their minds, and the only notice taken of it at that time was that they set it for the subject of some Greek verses (laughter), and all the boys of my class had to rack their brains to write some iambics on a subject of which we knew nothing, and to bring it into connection with the mythology of the ancients, of which we knew a good deal. I refer to this for the purpose of showing you how little science was promoted at our public schools. I am glad to say that things have been changed since (cheers); but much has to be done in this direction, and there cannot be a doubt that, if this country is to hold its own in the great industrial competition, it must give a greater place to science in our schools and equalise the endowments between the classical and scientific studies (cheers), and it is only by doing that, I am persuaded, that we can hold our own. We have been proud of the past in respect of science. Sir Lyon Playfair has already spoken of that branch of scientific men who devote themselves to pure science. It is my duty to propose the toast of that class of scientific men who devote themselves to that part of science connected with the industries and commerce of this country (applause), to the mutual advantage of both; for if science has multiplied the commerce and industry of this country a hundred fold, it owes it to men who have devoted themselves to applied science, and many discoveries could not have been made if it had not been for the important impetus which the industry of the country had applied to them (applause). I doubt whether there is any country in the world where there is a more devoted band of scientific men to the branch I speak of (hear, hear), and in the two great societies, the Civil Engineers, and that concerned with telegraph engineering, we have two bodies of men who have conferred inestimable benefits on the country. The one has supplied the country with all its railways, and has carried the capital of England to every part of the world, and has constructed railways in India, and given the model of them to many other parts of the world. I need hardly say that the telegraph engineers have given to England a monopoly of submarine telegraphy throughout the world (cheers) which has been an enormous advantage to the country. I beg, therefore, to conclude by proposing "The Societies Representing Applied Science," and to couple with it the names of Mr. Bruce and Mr. Latimer Clark (cheers).

The toast was duly honoured.

Mr. BRUCE, in responding, said: My Lords and Gentlemen—There is manifest fitness in the arrangement by which the recognition of science takes precedence to-night of the recognition of the application of science. It is in the latter and humbler walk that the engineer may be said to tread. The student of pure science follows it for its own sake. He dives into the mysteries of Nature from the pure love of making it reveal to man something which he did not know before (hear, hear)—a lover of seeking rewarded by the satisfaction of finding. The engineer, on the other hand, is the humble attendant upon the man of science, and when this man of pure science reveals some new law, then it is clearly our duty to try and find out some means by which that addition to the world's knowledge may be made to add to the world's wealth and happiness in things material. I think, gentlemen, we also have been very successful in the past in this department of the world's work, and we need no other testimony with regard to that than the position of telegraphy to-day, with the marvellous changes which it has wrought in the social life and in the commerce of the world, as we have heard early this evening from so many speakers. In fact, there is not the least doubt of it that the most marked feature of the reign of our Most Gracious Queen, and that by which it will be distinguished all down the ages, is both the application of science upon sea and land, in order to ameliorate and lessen human labour and to make the powers of Nature work for man (applause). That you have coupled to-night with this beneficent enterprise the Institution of Civil Engineers, which I have the honour to represent, I heartily thank you. We have faith in our mission because, although the instrument which the engineer may be said in the main to use for the advancement of human progress is iron, still we think we see in the forecast of the future indications that the golden age is before and not behind us (applause).

Mr. LATIMER CLARK, who was received with cordial applause, also responded. He said: My name is associated with that of the President of the Institute of Civil Engineers because I am intimately acquainted with the history and development of the Society of Telegraph-Engineers, and because the subject which the telegraph engineers have taken to themselves is one which is specially interesting in connection with the present Jubilee. Now the society, as most of us know, began in the year 1872, and was founded by the late Col. Sir Francis Bolton, who we all deplore, and by another gentleman, who I am happy to say is with us to-night, Major-General Webber (cheers). The society has had a career of great prosperity and success. It has increased in numbers, in popularity, and in usefulness day by day, and I am happy to add that its finances are in a sound and satisfactory condition. But it is not by success and prosperity that we are to measure its importance. We owe our importance on the present occasion to the fact that we are connected with the science of electricity, and that we deal with a fluid or power which has the most wonderful properties. These properties are little understood and little known, but the importance of their application is obvious to all mankind.

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In the first place, electricity is marked above all things by its wonderful power of propagation. It has a mysterious connection with all the other forces of Nature—energy, light, and heat. There is a charming simplicity about its laws which has engaged the attention of all the scientific men of the period. We produce results which are apparently marvellous in the eyes of mankind; we produce effects which are most brilliant. We are able to utilise the powers of this wondrous fluid or power for almost all the purposes of life; and, lastly, there lies before us obviously an unknown future, but one which must be of great importance to mankind. It is a fact that it is this peculiar agent which gives our society the importance which I feel it possesses. It is natural that the society should have lost many of its members. I have to deplore the loss of some men whose names are on the pages of history. I need only allude to such names as those of Cooke, Wheatstone, and Morse, and other men equally well known to you—Ronalds; we cannot name Faraday as one of the members, but he is one of those who have gone before in this matter. I am happy to feel that we have here to-day other names which are equally splendid. We have with us this evening one man who, by a singular fatality, is not a member of the society, but who certainly ought to be. We have with us this evening Mr. Jacob Brett (cheers). He undoubtedly is the father of submarine telegraphy. We have heard stated with great eloquence this evening the results achieved by submarine telegraphy; we heard from Mr. Pender the wondrous extent to which it has been carried; we have heard from Sir William Thomson, with his usual eloquence, the marvels of the Atlantic telegraph; we know that the highest honours have been deservedly bestowed upon those who were connected with it. But by some accident we have forgotten that before the Atlantic telegraph existed there were such things as submarine telegraphs, and that submarine telegraphs had arrived practically at full perfection, and the men who had brought it to that perfection were Mr. Jacob Brett and his brother, associated with others who deserved equal honour and credit (cheers). The Atlantic telegraph itself was brought into existence through the efforts of the brothers Brett, and I think we do an injustice to the science of electricity and to the art of submarine telegraphy when we forget them in the history of the subject. There can be no doubt that some seven years before the Atlantic telegraph they had successfully laid and put into working order a system of telegraphs which was in every respect the type of all the telegraphs of the present day; therefore, I say we are doing an injustice if we do not remember that these men were the real pioneers of submarine telegraphy (cheers)—if we do not remember also that when the centenary of submarine telegraphy comes forward in 1950, the names of the Bretts must be prominent as the originators of submarine enterprise (applause). I had forgotten the name of Siemens; I do not know why, for I intended to refer to it. No greater name will go down on the roll of famous scientific men (applause). There is one other subject I would mention to you. In the circumstances of life I have been entrusted with a number of valuable documents connected with the history of electric telegraphs. I was entrusted by Sir William Cooke with all his private letters and papers on the subject; I have have entrusted by Mr. Jacob Brett with all the interesting documents which he possessed connected with the establishment of submarine telegraphy; I was entrusted by Prof. Morse with some of the earliest specimens of his inventions connected with the electric telegraph, signed with his autograph. I feel that I have arrived at a period of life when it is prudent that I should relinquish that charge, and I now desire to state publicly my wish to hand those documents over to the custody of the Society of Telegraph-Engineers (cheers). I might now have ended by merely thanking you in the name of the Society of Telegraph-Engineers for the very kind manner in which you have received the toast; but the toast is that of the societies which are connected with applied science, and when I think of that toast I am emboldened by the patience with which you have listened to me to make one other remark, which shall be a very brief one. I feel that we, as the representatives of applied science, have been somewhat neglected by the world. I feel that the politicians, some of whom have honoured us by coming here this evening, have very much neglected us. I do not allude to honours, for we shall be very well content with the position of things in that regard; but I feel that they have robbed us of much of our credit, and that the great effects of the Jubilee which we are now assembled to commemorate have been due to the agency of applied sciences. I do feel that politicians have been permitted to claim for themselves the credit for the wondrous benefits civilisation has received from the efforts of applied science. We hear that so many shillings have been taken off a quarter of wheat, we hear that all the prosperity of the country has been due to free trade; but I say it is not so, I say they have robbed us of our honours in saying that. I say as guild and craft we ought to proclaim loudly to the world that to our efforts most of all the prosperity of the last fifty years has been due (hear, hear, and cheers). The population of this great city and of this country when it eats its breakfast to-morrow morning will be consuming food a very large proportion of which has been brought to this country by means of applied science (applause). It is that which has given us our prosperity. They have not taken 5s. or 10s. a quarter off wheat and other corn and eatables, but they have taken off 60s., 80s, and 100s. Wheat will be brought to-morrow from places from which it could not have been brought fifty years ago for ten times what it now costs. As a guild and craft we ought to proclaim loudly that the benefits which we have conferred are the real cause of the prosperity of the great Victorian era which we meet here to celebrate (cheers).

The Earl of ONSLOW: Mr. Raikes, my Lords, and Gentlemen—I am sure that you will be glad to hear from me the announcement that to my hands has been entrusted the last toast of the evening; but although it is the last toast, it is by no means an unimportant one. It is that of "Our Chairman this evening, the Postmaster-General" (cheers). Mr. Raikes is the head of the most important system of telegraphy in the world. It is true he is only the temporary head, and I for one at least hope that he or one of his own political complexion may long occupy that place (laughter). But, gentlemen, it is not only in my own personal and individual capacity that I am anxious to say a few words upon this Jubilee celebration of the electric telegraph, but also as representing that department of the Government with which I have the honour humbly to be connected—I mean the Colonial Office (hear, hear). Much has been said during the present year of the desirability of drawing together the bonds of the mother country and her Colonies (applause), but I venture to say that of all those bonds there is none so efficient or so strong as those of copper and gutta percha which the science of telegraphy has invented (applause); and I am anxious to take this opportunity of expressing my gratitude to Mr. Raikes for the assistance which he rendered to us during the sittings of the late Colonial Conference, in doing all that lay in his power to draw together the great commercial interests of England and of her Colonies by means of communication by post and telegraph. I feel that in Mr. Raikes we have to-night a gentleman who has not only presided over us with very great dignity and efficiency (applause), but also one who has deserved well at the hands of this country in administering that department which contributes most to the welfare of the great commercial world over which the metropolis in which we are this evening seated is, I am happy to think, the centre. Gentlemen, I give you "The Health of Mr. Raikes, the Postmaster-General" (cheers).

The toast having been cordially drunk,

The CHAIRMAN said: Lord Onslow and Gentlemen—I have to thank you very sincerely for the very kind manner in which this toast has been proposed and received, and I can only say now, as I have said previously in the evening, that I feel that your kindness is much greater than I deserve. I can only say that in departing from a subject of such magnitude and such universal interest, if one has not the knowledge of an expert at least one can bring to it something of sympathy and something of humility (hear, hear). I have sat here this evening and listened to the speeches made by some of the most eminent men of our time. I have heard recounted some of the achievements of the heroes of this great and peaceable crusade, and

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I have come to the same conclusion as that recently enforced upon us by Mr. Latimer Clark that it is rather to the men of science (may I say especially to the men of applied science?) that the prosperity of this country during the last twenty years has been due than to the politicians of that epoch (laughter). I feel that it is one of the special advantages of the office which I have been called upon to hold that one comes to realise more fully than one otherwise might the great forces which are working under the surface of our complex society, and to realise how little is done by Parliamentary chatter or by political agitation compared with the great unmarked, perhaps, but resistless progress of the human mind (cheers), which is perhaps embodied in no particular aspect more thoroughly than in the progress of the telegraph system which we have met to celebrate (cheers). I have to thank you extremely for your kindness to me. Perhaps you will allow me before I sit down to read to you a telegram which has only just been placed in my hands, and which I think is a fitting climax to the festivities of this evening: "Kindly convey to Chairman of Jubilee dinner the following from the Cape of Good Hope telegraphists. Heartiest congratulations and fraternal greetings" (cheers). This, at least, is an evidence not only of the extension of telegraphy, but of the fraternal and cordial feeling which that extension entails, and I am indeed proud to be here to-night in the midst of them in assisting to celebrate this great and never-to be-forgotten Jubilee (loud cheers).

The proceedings were agreeably interspersed with a selection of music under the direction of the Electro-Harmonic Society, Miss Ethel Winn, Madame Florence Winn, Mr. Arthur Thompson, and Mr. W. G. Forington being the vocalists, each and all of whom acquitted themselves with commendable ability. No small share of the honours of the night fell to Mr. T. E. Gatehouse, who gave a masterly rendering on the violin of Mendelssohn's "Andante and Finale," which commanded universal admiration. Mr. Battison Haynes proved an accomplished accompanist.

The company separated at about half-past eleven.

In the course of the dinner the Postmaster-General sent a commemorative telegram to Her Majesty the Queen, who was pleased to return a gracious answer thereto. The full text of these messages is given below:—

(Copy of Telegrams.)

27th July, 1887.

Sir Henry Ponsonby, Osborne.

A large dinner party celebrating the Jubilee of the Electric Telegraph remember with gratitude and pride that all the progress has taken place in the happy and prosperous reign of Her Majesty, and under her fostering care.

(Signed) POSTMASTER-GENERAL.

Postmaster-General, London.

The Queen thanks you for your telegram. It gives Her Majesty much pleasure to reflect on the improvements which have been made in Wheatstone's great invention, which was first practically tested in her reign.

(Signed) PONSONBY.

TORONTO: A FAST ELECTRIC RAILWAY.—On the 5th of September the Dominion and Industrial Exhibition opens at Toronto, and several striking electrical effects are to be exhibited. The Toronto Electrical Co. are laying a railway track, over which it is proposed to run electric cars at the rate of forty miles an hour. This will be the first occasion upon which any really high rate of speed has been attained upon an electric line, although, of course, there has been no technical difficulty in the way of high speed.

CORRESPONDENCE.

PROF. FORBES' MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note that Mr. Voice, in his letter of the 17th, referring to the modified form of Webster's machine, says:—"The lines of force, as they go from one pole to the other outside of the magnet, are much more widely distributed and much less concentrated than they are near the poles; and given two conductors of the same area fewer lines would be found to act on the conductor at the middle of the magnet than on that at the pole." Now, the machine, as illustrated, appeared to me to have two conductors of presumably the same sectional area, which extended to all practical purposes outside the influences of the field. There was no question of the relative sizes of these conductors, but simply if existing theory could explain the cause of current in such a machine. If this be the question I still do not see any necessity for Mr. Voice's assumption. Had Mr. Voice shown the lines of force emitted from the side of his magnet, as well as those from the end, he would have seen the reason why a midway conductor cuts more lines of force than one at the end.

The pivot arrangement, shown further on, proves little, and till Mr. Voice can construct a pivot conforming with Euclid's definition of a line, I fail to comprehend how he is going to get his conductor outside the field without cutting some of the lines of force. Mr. Voice goes on to say, "Do not the armature cores of the Gramme, Siemens, and other continuous current machines revolve at a terrific speed through this rigidly fixed though apparently ethereal force? And does not this fact conclusively show that magnetism is separate from and independent of iron?" I am afraid I cannot see the force of this reasoning, which, if anything, goes to prove how intimately the field is connected to the coils through which the exciting current is passing.

Mr. Voice asks why a cylindrical bar magnet should not rotate axialy through magnetism as easily as the gramme ring revolves longitudinally through it. In the first place, a gramme ring, if constructed in the solid and permitted to generate currents, would not revolve easily through a magnetic field; and in the second place there is no connection whatever between the two assumptions. The magnet in the one is assumed to be revolving in and independent of its own field, whilst in the other the ring armature is revolving in the field of a fixed magnet.

A magnetic field undoubtedly gives to some extent when under the influence of a disturbing force, but this distortion may be regarded as a kind of useless friction; for if the whole of the force applied to the armature were converted into current, there would be no useless reaction in the form of an opposing force of this nature. When I made the statement referred to by Mr. Voice—that in an ordinary dynamo current is produced by the reaction of a condition that itself is instrumental in maintaining—I was puzzled to understand how this could be in the case of a permanent magnet. The field of such a magnet cannot exist without its material core, and yet Mr. Voice assumes the core to have no connection with its field when revolving round its magnetic axis, and capable of producing energy in the form of current by reaction on this field. If it really had no connection with its field, then I see no reason why this should not be; but, pray then, why is the core necessary at all?

Mr. Voice cannot see any point of analogy between a magnetic field with its core and the terrestial system. I do not see why there should be no analogy because the gases of our atmosphere can be weighed, &c. A magnetic field is, as he states, probably an ether field, and if so it is composed of finite atoms or molecules of mass as much as any other field of which the constituents are more apparent to our senses. It envelopes a solid, which has the property of attracting certain bodies, and exists as a system in itself. Our terrestial system is bound together by a force we call gravity; it is said to be an attractive force, but is more probably an impeding force due to ether impact. But whatever it be, it inter-

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links the whole, and causes both the material gases and earth to revolve together as a system. A magnetic field is also maintained by a constraining force, and as the field cannot exist without a solid core, analogy would lead us to expect that the core and field are as intimately interlinked by virtue of the magnetic force as the gases and earth of our terrestrial system.

Mr. Snowdon has placed the subject at issue in a clear light, but I do not agree with him respecting a molecular chain, nor do I see how on this theory the molecular constituting the disk armature of Prof. Forbes' machine would receive their necessary oscillations.

If, however, we divide the armature of this machine into a number of concentric rings, it will be seen that the outer rings, containing more mass than the inner, will have a lower E.M.F. induced in them than the latter, although the same number of lines of force be cut in each case.

Perhaps this action becomes clearer by aid of analogy. Let any of the inner rings receive the same quantity of heat as any one of the outer, the inner ring, having less substance, would then be of a higher temperature than the latter, and a transfer of heat action would take place between the two, till each had arrived at the same temperature. Hence it will be seen that the same amount of energy was imparted to each, with resulting differences in intensity or potential.—Yours, &c.,

N. G. THOMPSON.

4, Queen Victoria-street, E.C., July 26, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may help to elucidate the theory expressed in my letter in your last issue if I show how it may be applied to account for the currents exhibited in the experiments with a cylindrical magnet, as described by Mr. Voice in the same issue.

Mr. Voice accounts for the effects described by supposing the magnetism not to revolve, but it is quite unnecessary to take that view, contrary to what he supposes.

It is impossible for him to make the necessary contacts with his magnet without placing a conductor in its field which will in a measure "scotch" the lines of force as they go round with the magnet, and accordingly retard them so as to make them cut through the magnet itself in honest proportion. Of course, if other conducting masses be also present within the sphere of the bar's magnetism, their retarding effect on the rotation of the lines will also have to be considered.

Were the currents observed by Mr. Voice really in the proportion 1:2, or did he only predict that?—Yours, &c.,

Staveley Ironworks, July 22nd, 1887. R. SNOWDON.

[We have also received a letter from Mr. Scattergood, but it did not reach us in time to have the blocks cut for this week's issue.—ED. *E.*]

THE USE OF PARAFFIN WAX AS AN INSULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Whilst making a sparking coil we had an experience particulars of which may interest some of your readers, who may have had a similar failure, without being able to divine the cause.

The coil had been treated in the ordinary way with paraffin wax of low melting point; to increase its bulk for a mechanical reason it was cast in a mould with a harder wax. Previously the coil had given a very good result, but after this treatment it was with difficulty that any spark could be obtained. We are under the impression that the cooling and contraction of the wax in the interior of the coil after the setting of the harder exterior wax must have left the mass of the wax in the coil full of fissures, which undoubtedly must have been vacua, as no air could penetrate the already hard external coating. To test the accuracy of the aforesaid hypothesis, and, if possible, remedy the defect, we remelted and removed the whole of the harder wax. The spark after this was as good as at first.

We would remark that the same cause might detract from the efficacy of a coil with wax of *one* density if the exterior were allowed to harden first by rapid cooling.

As this difficulty might occur in other apparatus we would point out the necessity of cooling *very slowly* where wax is used for insulating purposes.—Yours, &c.,

L. S. M. PYKE, F.C.S.

Devonshire-place House, N.W. HARRY T. BARNETT.

MEASURING MAGNETIC INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Mr. Kapp's excellent paper "On the Pre-determination of Characteristics of Dynamos," we are told that "an experiment made once for all is sufficient to determine this constant for all sizes of a given type

Is the manner in which Mr. Kapp carries out this experiment the same as that employed by Dr. Hopkinson, viz., by putting a wire loop round a magnet limb, and afterwards round the armature, and by measuring the magnitude of induction by a ballistic galvanometer? or has he found another more workshop like method?

I should feel very much obliged to Mr. Kapp by his favouring me with an explanation.—Yours, &c.,

FREDERICK DREXLER, Electrical Engineer.

Vienna, V24, Straussengasse, July 22nd, 1887.

HOW WE SAW THE REVIEW AT SPITHEAD.

Long before this article reaches the eyes of our readers the splendour of the spectacle at Spithead on July 23rd will have been described in glowing language in the pages of the daily press. These facile writers, however, are unable, with all the witchery of word-painting at their command, to adequately describe the scene presented by the Naval Review then held to celebrate the Jubilee of Victoria. Nor must it be expected that pens ordinarily devoted to the dry facts of science can hope to pourtray with greater vividness the scenic effects of a day long to be remembered in history, and never to repeat itself to those who had the good fortune to be witnesses thereof.

The electrical profession is to be congratulated upon the part their handiwork has taken in the display. He would have been a bold prophet who in 1837 had suggested one tithe the conquests made by electricity during the half century that has elapsed, but to-day it plays by no means an insignificant *rôle* in the world's affairs. The representatives of the Telegraph fleet present at Spithead formed a startling and a splendid proof of the electrical progress of fifty years. The Telegraph ships, so far as we saw them, were the "Monarch," the "Silvertown," the "Seine," the "Mirror," the "Electra," and the "John Pender." The three last vessels belong to the Eastern Telegraph Company, the "Seine" to the Telegraph Construction and Maintenance Company, the "Monarch" to the Government, and the "Silvertown" to the India Rubber, Gutta Percha and Telegraph Works Company, better known as the Silvertown Company. Our coign of vantage was on the "Silvertown," and it may interest our readers if, after this brief introduction, we attempt to describe the proceedings of the day. By the kind and courteous attention of the Silvertown Company we were provided with a berth on board the ship. On Friday afternoon, repairing to Waterloo Station, it was soon evident that something of more than ordinary interest occupied the attention of the railway officials. Cabs blocked the approaches to the railway, and the enterprising travellers had to make their way on foot, to find the station crowded with passengers bound to Southampton or Portsmouth. Train after train filled and was despatched, and ultimately with little demand on our patience we found ourselves at Southampton. Friendly faces appeared and friendly hands were grasped, giving a hearty welcome to the incomers. The guests of the Silvertown Company will long remember the considerate manner in which creature comforts were provided, and bear testimony that no pains had been spared to render the trip as enjoyable and pleasant as possible. When those who were to sleep on board arrived at the "Silvertown," which was lying off Netley, they found familiar faces of others who had come round with the vessel from the Thames. "Music arose with its voluptuous swell," and song

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succeeding song, carried us well into the small hours of the morning. To the landsmen, the ship method of marking the passage of time by the striking of the bells recalls at this moment the words of Poe :—

What a world of merriment their melody foretells!
How they tinkle, tinkle, tinkle
In the icy air of night;
While the stars that oversprinkle
All the heavens seem to twinkle
With a crystalline delight,
Keeping time, time, time,
In a sort of Runic rhyme,
To the tintinnabulation that so musically swells
From the bells.

A brief respite in the round of gaiety, a short journey to the land of nod, a cheery awakening to "Coffee, gentlemen!" brings us to the morning of the eventful day.

Queen's weather is proverbial, and this year has proved no exception to the rule. Saturday morning then gave forecast of a glorious day. Netley Hospital loomed across the water clear and distinct. A further contingent of visitors arrived, and the "Silvertown's" anchor was raised. Quietly steaming towards the crowded waters at Spithead, the vessel ere long reached the lines of warships. The steamer moved slowly through the fleet and back again before dropping anchor near to the "John Pender." Who can describe the sight as it should be described? Ship after ship, gay with bunting, and as spick and span as only men-of-war can be, crowded with brilliant uniforms, burst successively upon the view. It is not our province to discuss the various types of ships—there they all were, from the swift torpedo boat and torpedo catcher, to the ugliest, heavily armoured, tower-topped and turretted modern engine of naval production. After going through the lines there was time to look around, and whichever way the eye turned it fell upon proofs of England's maritime greatness. Perhaps the most effective and certainly the finest sight of the day was the procession of troop ships. These vessels are acknowledged to be some of the finest specimens of naval architecture ever produced, and while æsthetic tastes have certainly not been consulted in designing our modern war ships, surely the most fastidious taste would find little fault with these beautiful vessels.

The Queen has started, and the sound of the signal gun bursts upon the ear. Immediately along the line the answering sounds arise as the salute of twenty-one guns announce the arrival of Her Majesty. The swirling smoke for a moment hides the vessels from our view, but the gentle breeze soon carries it off, and almost ere the last "boom" has sounded the air is once more clear, and from a hundred lips the words go forth "There she is!" as the Royal Standard is seen coming up the line of battle ships. The progress of the Queen's yacht is watched with interest, but we are too far off to hear the "hurrahs" of the sailors who man the yards of the vessels. On the return journey the yacht casts anchor in the middle of the line, and signals flutter in the breeze. Soon we perceive that these signals are to command officers to the Royal yacht, as boats put off from the various vessels within sight, all going towards the Queen's yacht. From the reports in the daily papers we understand that the Queen expressed her warmest approval of the pageant provided to do her honour. Some two hours were spent in this ceremony, and then the "Victoria and Albert" proceeded onwards. The departure of the Queen was signalised by a salute of twenty-one guns, as was her arrival, but the spectacular effect of this later salute was far more brilliant than that of the earlier one. A bank of dark cloud had arisen on the horizon, showing up as a background with great vividness the flashes of the guns. The spectator would see a flash of flame rushing out of the side of the vessel, and through the remnant smoke of the preceding discharge, followed by a whirling puff of smoke, and after that came the dull boom. Then all was silent. The smoke gathered in a cloud and was soon carried away shoreward. Again came a period of waiting for the grand firework display that was to bring the memorable day to a conclusion. But time did not hang heavy with those on board the "Silvertown," while some of the other vessels that had not previously gone through the lines took the opportunity of doing so.

Eight o'clock. A moment ago flags were fluttering in the breeze from every masthead, but simultaneously throughout the fleet the flags came down with a run. It was a pretty sight. Night came on apace, and now came also the time for the electricity to show what part it was to play in the spectacle. During the day curious eyes through powerful glasses had attempted to make out what preparations had been made on board the ships for the illuminations. Little, however, was to be learnt save that lines of incandescent lamps could be detected. As darkness spread over the water brilliant lines of light from incandescent lamps flashed out, now here now there, till the permanent lighting of the evening, if we may so term it, was general. From various mastheads, too, flashed out powerful arc lamps, giving a brilliant effect. Each vessel, also, had arranged incandescent lamps to shape the monogram "V R," the letters being in some cases over 14ft. in height.

A signal comes in the wild weird scream of the siren. Every one is on the *qui vive* to know what it means, when bursting upon the eye comes one of the most brilliant displays that it has been the lot of sight-seers to witness. From deck to masthead the men-of-war are illumined with red and blue and yellow lights, while clusters of rockets rush upwards through the clear air, bursting in a thousand brilliantly-coloured scintillations. Vieing with the men-of-war our own vessel enters into the pyrotechnic competition. From end to end of the bulwarks, from all our yards, sailors are placed, each with coloured fires. At a given signal the vessel is illumined, and cheer upon cheer from the surrounding ships show how successfully. Meanwhile flights of rockets are being sent up, and the largest and most brilliant of all the search lights upon the water sends forth a powerful beam, lighting up everything upon which it is cast. The sight-seers upon Ryde Pier feel its power and turn away from its direct beams. But soon these beams are curtailed, for the smoke is hanging thick over the fleet, fog has arisen, and the atmosphere is no longer clear. We hear the rockets hurtling up through the smoke, see the reflection of the light when they burst, but except when they pierce through the smoke cloud and burst in the clear space above the effect is somewhat marred. The scream of the siren has been heard again and again, bringing about concerted action far and near, each successive effort, perhaps, being more beautiful than the last; but to our eyes the most effective display was by the sailors playing at battledoor and shuttlecock with coloured balls of fire. This effect, so far as one could make out, was from a general distribution of Roman candles all over the decks and lower rigging, the coloured balls of flame thrown out by these candles describing all kinds of curves, intermingling in beauteous confusion, giving a *coup d'œil* which could hardly be surpassed.

But the crowning effect was to come. The signal was once more the wail of the siren, and instantaneously the brilliant beams from the search lights from every ship flashed forth. It is impossible to describe the scene. The direction of the beams had been privately arranged, and it will be understood that the effect was grand. At one time they would converge to a distant point on the water, at another time the brilliant beams of light were directed to a point skyward, forming a "crown of glory."

Here we conclude our report. In our estimation the most instructive lesson of the day was to be learned from the fleet of cable ships. We do not care to moralise, but the thoughtful mind could not but contrast these vessels, and their work, with those we went out to see.

THE EXPERIMENTAL LINE OF THE ELECTRIC TRACTION SYNDICATE AT SOUTHWICK.

On Tuesday last, upon the invitation of the Electric Traction Syndicate, the representatives of the technical journals were present at "a private demonstration of electric traction" on the line between Shoreham and West Brighton. The line itself was built by a local company some years ago, but has never paid its way, and it has been in the hands of the Syndicate for experimental purposes during the past twelve months, during

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which period an elaborate series of tests have been carried out. The total length of the line is about 4½ miles, and presents features which are of considerable value for the purpose in view. The gradients are numerous and in some cases exceptionally severe, rising to 1 in 20 where the road crosses a bridge at Southwick, and there are two sharp curves of about 28 yards radius, one of which is on an incline of 1 in 100. When to this it is added that the road has not been maintained in very first rate order, it will be seen that the line is particularly well adapted to test the capabilities of any system of traction. Indeed, it may be remarked that Messrs. Aveling and Porter, the engine builders, have been experimenting with a new type of steam engine upon the same line concurrently with the electric trials. The average coefficient of traction has been found to vary between 42 and 55lb. per ton, according to the state of the metals; upon a well-laid London line this coefficient does not usually exceed 30 to 35lb. per ton.

The engineers of the Syndicate are of opinion that while electric traction upon lines where the cars follow one another at short intervals is best applied upon the cars themselves, yet that a wide field exists for the use of electric locomotives upon suburban lines where heavier loads are carried at longer intervals, and the conditions approximate more nearly to those of a railway. The trials upon Tuesday last began, therefore, with a short run upon an electric locomotive car weighing about 12 tons, and designed to draw a bogie car, with seats for 60 persons, at a mean speed of 8 miles an hour, additional accommodation for 14 persons being provided upon the locomotive itself. The motive power is obtained from a set of 168 A size Tatham cells, discharging at 50 to 60 amperes, with a capacity of 200 ampere hours. The motor, which is of the Immisch type (SM9 on their list), series wound, runs at 650 revolutions. The armature is 9in. in diameter, and is geared direct to the driving wheels by pinions at each end of the spindle, which mesh with internal teeth upon a circular rack on the wheel. The ratio of the teeth is 10 to 67. The motor is suspended by sleeves on journals cut in the axles, which are of steel, and has a tension bar from the centre of the fields to the end framing, to act as a fulcrum. But although this gearing has given good results in practice, yet it has been considered desirable to seek for a less expensive form of gear of equal efficiency; this having, it is believed, been found, it is not intended, as a rule, to resort to the arrangement just described. For this reason the trip of the locomotive was not of great length, nor were any measurements taken.

Returning to the engine house at Southwick a self-contained car was next tried, upon which the party made the journey to Shoreham. At this place a halt was made for lunch, and afterwards the car traversed the whole length of the line to West Brighton, attaining a mean speed of slightly over 11 miles an hour; the maximum speed probably approached 16 or 18 miles an hour on some of the inclines. This car is capable of seating 20 passengers, and by itself weighs one ton; the weight of motor and gearing is one ton, and the accumulators 1·75 tons; a total rolling load, when full of passengers, of about 5·25 tons. The wheel base measures 5ft., and the wheels are 2ft. 6in. in diameter. The cells, which are eighty-four in number, are of the Tatham type, B size, with a normal discharging rate of 45 to 50 amperes, and a capacity of 150 ampere hours. They are divided into two separate batteries, each battery being again divided into two halves. By means of a suitable switch, designed by Messrs. Immisch and Co., the two halves of each battery can be connected either in parallel or in series, and the two batteries can also be connected in parallel or in series with each other. Out of these four possible arrangements it will be seen that two amount to the same thing electrically, so that only three different speeds are obtainable by this means. In actual practice it has been found that these three speeds fulfil all requirements.

The motor is again of the Immisch type (SM7), series wound, and runs at 1,000 revolutions with 160 volts and 40 amperes. The experiments carried out by the Syndicate have largely been directed to the question of heavy motors running at slow speeds geared direct, *versus* lighter motors running at higher speeds with second-motion gear. With slow speed motors the question of weight assumes great importance, not only because the motor itself must necessarily be comparatively heavy, but because at slow speeds the torque is so great that the gearing and all structural parts connected with this or the motor have to be additionally strengthened. These additions to the dead weight, combined with the slower speed, necessitate also a greater current in starting and upon inclines, and thus reacts injuriously upon the batteries. A speed as low as 350 revolutions has been tried, but the experience gained has led to the conclusion that a considerably higher speed is desirable, even although the gearing becomes more complex. The motor now preferred runs at 1,000 revolutions, and drives by means of chain gearing.

The chains are of a type specially designed by Mr. Hans Renolds, of Manchester, and the links are exceptionally heavy. By means of an intermediate shaft the speed of the driving wheels is reduced in the proportion of 1 to 9, and means are provided for taking up the slack of both chains by shifting the journals. The gearing runs with great smoothness and an almost entire absence of noise; in fact, the car runs without more noise than a horse car.

The motor weighs about 5½ cwts., and has an efficiency of conversion at full load of 85 per cent. Its average working efficiency probably lies between 75 and 80 per cent. By winding the armature with smaller wire this could probably have been increased without reducing the normal output; but the element of safety which exists in an armature capable of taking an excessive current would be reduced in proportion. In this case the factor of safety as regards the sectional area of the wire is so great as to admit of the car being stopped and started upon an incline of 1 in 20. It was proposed on Tuesday to repeat this experiment, but time did not permit. The current, however, probably exceeded 100 amperes under this test.

The readings of the ammeter taken during the run showed that under an E.M.F. of 80 volts the current averaged 35 amperes on the level at a speed of 8 to 10 miles an hour, rising to 45 amperes on an incline of 1 in 120. When the cells were placed in series, giving a terminal E.M.F. of 170 volts, the mean speed increased to 12 or 14 miles on the level with a current of 45 amperes. On the incline of 1 in 20, and going round the sharp curves, the current increased to 80 amperes. These figures are little more than approximate, but were taken as a rough verification of the results obtained by more careful tests made at leisure by the engineers of the Syndicate. The limits of our space do not permit us to give a specimen of these tables in our present issue, but we shall probably return to the subject at an early date.

The Electric Traction Syndicate is certainly to be commended for the careful and thorough manner in which they have proceeded to work out the numerous problems connected with the details of the subject; and especially for their determination not to come before the public until a long series of trials of a thoroughly practical character had enabled them to undertake business with perfect confidence in their ability to carry it to a successful issue.

COMPANIES' MEETINGS.

Submarine Telegraph Company.

A meeting of the proprietors of this Company was held at the offices, 2, Throgmorton-avenue, London Wall, on Monday last, under the presidency of Sir Julian Goldsmid, Bart., M.P.

The SECRETARY (Mr. S. M. Clare) having read the notice convening the meeting, the Company's seal was affixed to the register of shareholders.

The CHAIRMAN: Gentlemen, I have to make a few observations on the report, which I expect you will allow me to take as read, as you have on previous occasions. You will observe that there has been a fair increase of traffic, but I, for my part, do not consider that that increase is altogether normal. I have several reasons for that opinion. The first is, that it is a surprising fact that there was an enormous increase of messages owing to the earthquake in the Riviera last winter—that was early in the year. The second is, that shortly afterwards there was an alarm of impending war between France and Germany, which caused an immense amount of telegraphy between continental countries and England; and the third was, that it happened that, in consequence of the vast number of august visitors who came to this country in honour of the Jubilee, there was a large temporary increase in the number of messages. I regret to say, therefore, that in my opinion this increase, which is satisfactory so far as it goes, does not appear to be a permanent one owing to there being temporary causes to account for it. But there is one other satisfactory fact

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to relate, and that is that practically, for the present at least, we seem to have come to the end of the fall in the number of words which are comprised in each message. That is a matter so important that it is specially stated in the report, and you will there see how it stands. On the whole, I do not consider that the position is unsatisfactory, because if we have come to an end of the fall in the number of words per message, there must be before long a steady increase in the business of this Company as there is in the business of the world generally. I think that you will probably expect me to say something about the future of this Company; but on the whole I believe the less I say the better it will be, because, first of all, we have still rather more than a year and a half to exist under present conditions, and what the future conditions may be I am not in a position to say. You will have observed that questions have been asked of the Postmaster-General in the House of Commons with regard to his wishes with respect to the end of our contract, and I believe similar questions have been addressed to the French Minister in the Chamber of Deputies, and both ministers have observed a due reserve on the subject, merely saying that it would occupy their attention. It appears to me that although I do not occupy so important a position as a minister, still, as your minister, if I may so speak, I consider it is my duty to say that we shall do all that we can to maintain the interests of this Company, and that we must ask you to show us that confidence which you have hitherto placed in us. There is another point upon which I might say a word, namely, that our former Director, Mr. Robert Bourke, who is now Lord Connemara, left the Board when he was appointed to the high office of Governor of the Presidency of Madras. I was in hopes that we might have secured the services of a most illustrious man—there is no need to mention the name—to fill his place, but we did not succeed, although I am glad to think that we have obtained the services of an able and intelligent gentleman, whose name will be submitted to you for approval—Mr. Gathorne Hardy, the son of Lord Cranbrook. He is a most experienced gentleman, and capable of giving us valuable assistance, and in securing him we have, I think, secured a valuable addition to the Board. That is the sum and substance of what I have to say to you. I do not think there is anything special in the present condition of affairs. I believe that we shall have quite a normal half year, and that at the end of it I shall have to report to you certainly not a large increase, if, indeed, I have to report any increase at all. But, on the whole, considering that our property is in good order, and that we have done our best to satisfy the public, in whose interests we work as much as in those of the shareholders, I think we may congratulate ourselves on our present position, and I have much pleasure in moving the adoption of the report.

The Hon. ASHLEY PONSONBY seconded the motion.

A SHAREHOLDER wished to be informed what was the basis upon which the proportion of the receipts as between the two companies was calculated.

The CHAIRMAN said they were aware that the French was the original company, but the English one was established subsequently for the purpose of adding to the number of cables, and it was by arrangement between the two companies that it was deemed easier to obtain capital in England under the circumstances than it was in France. They must remember that in the early days of its existence the Submarine Company worked, like many other pioneers of useful work, without any remuneration at all, and people who talked about their receiving large dividends now should bear that fact in mind. What they now received went to counterbalance their early bad fortune and give them just a fair average dividend. The proportion of receipts as between the two companies were represented by the figures—English 83·6, and French 16·4.

The motion was then put, and carried unanimously.

The CHAIRMAN next moved "That, in accordance with the recommendation of the court, a dividend for the half-year at the rate of 12 per cent. per annum, payable on and after the 1st September next, be now declared." He might mention that the meeting was held a week earlier than usual as a matter of personal convenience to himself, and, he hoped, at no inconvenience to the proprietors.

The Hon. H. R. BRAND seconded the motion, which was agreed to unanimously.

The retiring Directors, Sir Julian Goldsmid and the Hon. E. Chandos Leigh, Q.C., were subsequently re-elected to their seats at the Board, and the appointment as a Director of the Hon. J. S. Gathorne Hardy, M.P., was confirmed.

The auditors, Messrs. William R. Cole and Thomas Dakin, were then re-appointed, and the proceedings terminated.

Anglo-American Telegraph Company (Limited).

The half-yearly general meeting of the proprietors of this Company was held at Winchester House, 50, Old Broad-street, on Wednesday, under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the minutes of the last half-yearly meeting, which were signed as correct by the Chairman.

The CHAIRMAN: I presume, gentlemen, that you will take the report as read. That being so, it now becomes my duty to move its adoption, and in doing so to make a few observations on the working of our institution for the last half year and our prospects. The first observation I am led to make is that during the past half year we have carried a very large volume of traffic, and have done it most efficiently. In fact I am tempted to tell you a little anecdote which I heard the other day, to show the efficiency of the working. I was told that a gentleman who wished to get an answer from New York in the shortest space of time had an answer in either four or five minutes, and he was so incredulous that he went back and had the message repeated. He could not believe that the answer had come in, and he was quite willing to pay, in order to satisfy his curiosity a second time. The volume of traffic, as I said, has been very large; but I am sorry to say that when turned into £. s. d., it is not quite so satisfactory. We have, however, whatever satisfaction may be derived from the fact that the figures which are open to us lead us to the conclusion that the pecuniary position of our rival is not a happy one either; and therefore it seems that the hardships from which we are suffering are rather in the nature of things than resulting from anything defective in the management of your Company. I will not attempt to give you any figures showing the increase of the traffic as compared with former periods, and for several reasons, which I will tell you. In the first instance, if we compare with the corresponding period of last year we should not be comparing with a period during which we were carrying our traffic at the same rate, and therefore the comparison would be entirely fallacious and misleading. In the next place, if we compare with the previous half year, during which we were carrying at 6d. a word, our experience is that the second half of the year is always a great deal more productive than the first half, and that in itself would vitiate the comparison also. There is another element in the matter not to be neglected, that is, the withdrawal of the French company from the "pool," the right to which withdrawal we, of course, dispute; but that is only in a parenthesis. That fact, however, would also introduce an element into the accounts which would render any comparison fallacious I therefore will not trouble you with any comparison of the dates, but content myself by saying that the 6d. tariff has brought a satisfactory and substantial increase both in the first half year in which it was in operation and in the second half year, which is the bad half year as compared with the first half, which is the good half. Gentlemen, so much with respect to the traffic; now with respect to our plant. I may tell you that our whole system is in excellent condition, with the single exception of which you are all aware, as it is alluded to in the report—the breakdown of the Brest-St. Pierre cable. That is the oldest Atlantic cable in existence, and it was still working up to the time of the break. The break took place in November, and perhaps some observations may be made as to why we did not send at once to repair it. But gentlemen who are conversant with cable work in the Atlantic know that it would be absurd at that period of the year to send out an expedition to repair a cable. The ship, I believe, is now on the ground, and in the act of repairing the cable. The period which intervened has not, however, been lost, because we have used our ship in taking soundings in the neighbourhood of the break, which I expect will be very useful to us in making the repair. If you look at the accounts you will see that we have earned £6,000 by the hire of our ship in the meantime. As I told you, the plant is in good order. As to the accounts, I do not think there is any peculiar feature in them. The expenses are a little higher than in the corresponding half of last year; but we have been carrying an enormous additional traffic, which cannot be carried without additional cost. So much as to the past. With respect to the future, I have very little to tell you. You have all probably seen reports from the New York newspapers with respect to discussions for an arrangement of the difficulties between the companies, and all I can say is this, that you are aware of the proverbial connection between fire and smoke, and from that I am led to believe that such communications may have taken place; but as far as your Company is concerned, or our sister Companies, we have had no proposal laid before us with which we could deal, and therefore, as far as I am concerned, and as far as you are concerned, we are precisely in the same position with respect to competition for the traffic that we were in when I last addressed you. When I announced to you this time last year the adoption by your Directors of the policy of trying at a low rate to stimulate the traffic—which policy, by the way, was, as far as I could see, accepted very favourably in this room—I told you that it was a policy that I believed in the long run would be successful, but that it was one which in the meantime would make considerable drafts on your patience and forbearance. Now, that is the case. The traffic has been stimulated, and has very largely increased, and is increasing, but it has not yet reached a point at which we can pay you anything like a satisfactory dividend. On the other hand, we are very much in the hands of others with respect to any change of policy. I do not advocate a change, but if we wish for it we are in the hands of other people in a large degree. We cannot make a change without the consent of other parties, and those parties as yet have given no indication either of their intention or desire to make any change. Gentlemen, this is a matter upon which I do not want to dogmatise or to lay down any hard or fast lines, or to use any expression which would interfere with any arrangement that might be considered advisable for the companies to adopt. I told you this time last year that we adopted the 6d. rate not as preferring 6d. to any other figure, but because it was a very low rate, and one which we expected would have the effect of stimulating the traffic. I still hold that opinion. I have the most confident conviction that if by any arrangement we were to raise the rate at present by a large figure we should infallibly have additional competition. That has been what has resulted from this arrangement in former times, and I believe the experience derived has led your Board to the conclusion that such a proposition would be highly inexpedient. My own conviction is that we ought to go on—I do not say at 6d., or at 1s.—but that we should fix the rate at a very low figure, and go on in the hope of stimulating and increasing the traffic, and thereby making a livelihood for ourselves. I think it is essentially—eminently—a case in which you ought to trust your Directors. If you do not think we are managing your business satisfactorily, and to the best of our ability, and as well as it would be managed by others, I should advise you to get rid of us, and to get those who you think could do better for you; but as long as we are your Directors, and you continue us in that position, I must ask you per-

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sonally, and on behalf of my colleagues, not to give us a half confidence. We are doing all we can. We are endeavouring to economise in every way, and we hope the continuance of our policy will enable us to pay you, if not a large dividend, at all events a satisfactory one. With these observations I leave the matter in your hands, and I beg to move "That the report of the Directors and the accompanying statement of accounts to the 30th June, 1887, submitted to this meeting, be, and the same are hereby, received and adopted."

The Marquis of TWEEDDALE formally seconded the motion.

Mr. THOMAS SMITH (York) said he would support the adoption of part of the report, but he could not approve of the whole of it. He agreed with the Chairman's remarks as to the 6d. tariff; and the improvement in the traffics compared with the corresponding period of last year was very encouraging, and showed, to his mind, that the 6d. rate was an increasing success. For four months of the corresponding period of 1886 the 1s 8d. tariff was in force, as against 6d. in the whole of the past half year. The December half year they always considered, as the Chairman had said, the better half year, and in that half year they brought forward a balance of £2,423, leaving the net takings for the six months £87,384, compared with £100,534 in the six months now under review—to the 30th ult. In making that comparison, it must be remembered that they brought forward not a farthing in the half year just closed. After what the Chairman had said, he thought they might look forward with confidence to the coming half year, the best half of the year. He believed that they would consider with him that the sixpenny rate was progressing very satisfactorily, and that they had nothing to do but to sit still and work at it. In his opinion the future policy of the Company must be based on the 6d. tariff. Let them give it two or three years' trial. They would suffer from the want of dividend during that period; but he was quite willing, though a large shareholder, to forego his dividend for the present—that was, if the Directors would be fair towards them and divide what the Company earned. He did not agree with the Directors' policy as regarded the third paragraph of the report. At the last meeting the Chairman asked the shareholders for their patience, forbearance, and support, and he (the speaker) thought they had granted that request right loyally. Taking that into consideration, and the fact that nothing had been brought into last half year's account, he thought the Directors should have made the dividend on the ordinary stock 10s. per cent. and on the preferred stock £1 per cent. After the shareholders had suffered as they had, the Directors ought to meet them in the most liberal way, instead of proposing to carry forward a balance to the next half year of 50 per cent. of the net earnings of the last six months. Such a proposal he regarded as preposterous. And what were they carrying it forward for, seeing that they had £84,500 uninvested? He did not think it could be said that there was any shortness of money, with £84,000 doing nothing, and for which they had received £165 as interest. At the meeting last February, too, they were promised a detailed list of the investments.

The CHAIRMAN: Have you not got it in the report?

Mr. SMITH said he did not consider it a detailed statement, such as that given by Mr. Pender in the case of the Globe Telegraph Company. There was an item of £13,000 given as "other securities." Was that a detailed statement? Such a statement would only have to be done once, and it would really cause practically no trouble. He was glad to hear the Chairman speak about economy, but he could find no evidence of it in the accounts. In conclusion he moved as an amendment, "That the report be adopted, with the exception of the part of paragraph 3 which states that £18,323. 6s. 8d. be carried forward, and in lieu thereof that a dividend of 10s. per cent. be paid on the ordinary stock and 20s. per cent. on the preferred stock."

Mr. C. E. DAVISON seconded the amendment. The Directors must be aware that for a long time the shareholders had suffered from the want of dividends, and it was only right that, instead of £17,500 being now distributed, £35,000 should be divided among them, which would be the effect of carrying Mr. Smith's amendment, and which he urged the Directors to support.

The CHAIRMAN: I am not now going to answer Mr. Smith's observations, but I wish to say a few words about his amendment, as to which it would be perfectly useless and a waste of your time to have any discussion. I am precluded from putting it to the meeting by the Articles of Association. The shareholders cannot declare any larger dividend than that recommended by the Directors, and I should be forfeiting all claims to your confidence, and should be violating my duty if I put this amendment. I have the greatest possible sympathy with the shareholders. The fact is that this is an interim dividend. We retain this fund in our hands, but it is only an estimated surplus. It should be remembered that we are engaged in litigation with the French Company, and that we have at this moment a very expensive repairing expedition going out. We may require money for that, and at all events we have to the best of our judgment done what we thought was for the true interests of the shareholders in declaring this interim dividend, with the prospect that during the year we shall be able to give them something more.

Mr. WILLIAM ABBOTT said he had been very pleased to find Mr. Smith—a gentleman whose remarks at the meetings were deserving of every respect—so strong an advocate of supporting the Board in the policy they had adopted respecting the 6d. tariff. He himself at the last meeting had not agreed with that policy, because he had thought it desirable that some arrangement should be made by which the tariff should be raised to 1s. He had, however, completely altered his opinion, for the 6d. tariff did not suit their competitors at all. He thought they should continue the tariff, and wait and see the result. At that meeting he was particularly desirous that they should give a unanimous support to the Directors. He did not think the detailed information respecting the cost of the securities of the renewal fund was necessary, and what he himself admired about the report was its simplicity. They had securities valued at £882,000, with £84,000 uninvested. He thought it would be very satisfactory if they could be told whether the present market price of the £882,000 was in excess of the actual cost price of the securities. He begged the Directors to invest nothing further in the Canadian Pacific Railway Company.

The CHAIRMAN: It is a first mortgage.

Mr. ABBOTT said he had no faith in the Canadian Pacific Company. He was glad to see the legal expenses so small, and astonished to see Mr. Burt looking so well notwithstanding. He regretted that Mr. Smith had spoiled his statement by the amendment which he had proposed, and he thought that they should on that occasion show their competitors that they were "full of fight." He would be sorry to see distributed the £18,000 which the Directors in the report had suggested should be carried forward.

Mr. GRIFFITH said he considered that the argument adduced by Mr. Smith in support of his amendment was unanswerable. He maintained that the £84,000 referred to ought to have been invested to produce 3 per cent. at least. He entirely agreed with Mr. Smith. As to the amendment, the Chairman took a very restricted view of what the Articles of Association provided. They could put the amendment in this way—that they would not receive the report, that they would send it back, and that unless the Directors would declare the extra dividend which Mr. Smith proposed, they would not pass the report. Remembering the additional expense involved by the increased work that had to be done with a sixpenny tariff, he reckoned that they would have to earn four times the amount they had earned with the 1s. 8d. tariff before they could even attain the wretched position they were in with the higher tariff. He supported the amendment. The time had come when the Articles of Association should be altered.

Mr. JOHN NEWTON contended that the revenue earned by the reserve fund ought to be added to the general revenue of the Company, and not put to the fund.

Mr. HERBERT SMITH (Gray's Inn) maintained that it was unnecessary to carry forward the sum of £18 000 as proposed in the report.

Mr. HUMPHREYS wished to know why it was that the £84,000 had not been invested. He viewed the report in an unfavourable light, and he believed that the reduction in the tariff from 1s. 8d. to 6d. was an act of temper, the whole circumstances of the case not having been taken into consideration.

The CHAIRMAN: I regret very much that we have not the admiration for our report of the gentleman who has just sat down, but I think he takes rather a prejudiced view of the conduct of the Board, because he says that the adoption of a 6d. tariff was an act of temper. I can only say that so far from being an act of temper, when one commits an act under the influence of temper one acts hastily, but I never, since I have been on the Board—now for a good many years—remember any act that was taken with greater deliberation, more circumspection, and more consideration of all the circumstances of the case. The gentleman has also said that the rate would never rise beyond 6d. That view is certainly not derived from any observation I have made, for I guarded myself most carefully in saying that it was a low rate we went in for with a certain object, and that we can never bind ourselves to any particular rate as one we would arrive at. So much for Mr. Humphries. I now proceed to answer as well as I can the different observations made. Mr. Smith took occasion to animadvert on the amount of the dividend, and said it might have been 10s. per cent. He is quite right. It might have been 10s. per cent; but had we declared a 10s. dividend we should have divided up very closely on a balance which was only an estimated balance. I wish the stockholders to remember that this is not the final dividend. This is merely an interim dividend. You will, I hope, receive another and I trust a larger dividend next quarter.

A SHAREHOLDER: You told us that six months ago.

The CHAIRMAN: I do not pretend to infallibility, and if I did venture to prophesy I think it probable that I might have been incorrect. But still I had not the same ground then as I have now, because we have now, so far as an estimate goes, the money in hand, and we shall pay up as closely as possible in the next half year. Mr. Smith and some other gentlemen made some observations about the uninvested balance of the reserve fund. That balance is a sum which is probably not yet paid. Another portion of it is a sum which we shall have to pay in the course of a few days for the expense of the repairs; and now I put it to any of those gentlemen—I ask Mr. Abbott, as a practical man, does he think it would be wise for us as directors to invest money, incurring the expense of stamps and brokerage, which we should have to pay in two or three months?

Mr. ABBOTT: You must pay the broker.

The CHAIRMAN: We have sent out 300 miles of cable, which has to be paid for. It is really to save the money of the Company that we do not invest this sum. Then there is a small amount of £13 000 of which Mr. Smith made a great deal in point of argument. I wonder if Mr. Smith has ever read such a thing as the account of a charitable subscription, where a number of small sums are put down under one total. This £13,000 is put down here on the same principle. They are small investments not worth fully mentioning; but if Mr. Smith has the least curiosity he really only has to go to the offices of the Company and Mr. Wells will tell him.

Mr. SMITH said that he wanted the information not merely for himself, but for the benefit of all the shareholders. They could not all go to the offices for the information.

The CHAIRMAN: I think if you get the information respecting £382,000 it is taking rather a microscopic view of things to want the details about £13,000. Mr. Abbott asked what is the total value of the investments to-day. As nearly as we can calculate, taking the middle value, the securities are worth about £25,000 more than they cost us. As to the Canadian Pacific Railway, it was very good advice—[Mr. ABBOTT: It was only a hint]—given by a stockbroker to an investor who had come to consult him; but I do not think the Canadian Pacific Company would like such

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advice to be given and discussed at a public meeting. With reference to the revenue from the renewal fund, the whole question of that fund was the subject of an arrangement that was entered into between the Board and the committee headed by Mr. Smith. The result of that arrangement was that no further addition to the renewal fund, except the interest derived from the investments forming the fund, should be added to it after it had reached to £1,000,000. It is not £1,000,000 yet, although, to use a common phrase, it is "within measurable distance" of that amount. When we get to our million we will consider how the interest earned by the investments of the fund shall be disposed of with due regard to the interests of the shareholders. The only other observation I am led to make is with reference to something that was said by Mr. Herbert Smith about this £18,000. He said it is not going to be paid in dividends; but what I said was that we do not declare it now, because it is only an estimate. We mean, however, hereafter to apply it to the shareholders' benefit just as much as if we gave it now. I am sorry that we are obliged to reject the amendment of Mr. Smith, but I cannot put it, and I hope that he will withdraw it. [Voices: "Withdraw!"]

Mr. SMITH said he would take the Chairman's advice under the promise which had been made. He again asked that a detailed statement might be made in the accounts as to the cost of the investments of the renewal fund. Let the Directors take as their guide the information that was given by the Globe Company.

The CHAIRMAN said he thought he had in a great measure supplied the information asked for in stating what the price of the securities was at the present time.

The motion was then put in the usual way, and declared to be carried.

Mr. ABBOTT proposed, and Mr. THOMAS SMITH seconded, a vote of thanks to the Chairman and Directors. This having been unanimously agreed to,

The CHAIRMAN said: I am exceedingly obliged to you for your vote of thanks, which has been so constantly passed to us. I am particularly obliged on the present occasion, because I feel that there is a great deal which the shareholders have to bear, and which the Directors would not impose on them if they could help it.

The proceedings then terminated.

Cuba Submarine Telegraph Company.

The thirty-second ordinary general meeting of the shareholders in this Company was held on Wednesday last, at the Company's offices, 61, Old Broad-street, E.C., under the presidency of Mr. Joaquin de Mancha.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the Directors' report and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, I have again the pleasure of meeting you with a very favourable report, and I think that on the face of it very little need be said. Our business seems to go on satisfactorily. Our income has increased a little, although not so much as I should have liked, because we have carried a great many more messages in this half year than we did in the corresponding six months. Those extra messages amount to over 2,000, and the increase in our receipts has been only £547. People are getting so clever in the matter of telegraphy now, that the messages do not amount to so much as they did before. The report is so full that I need not detain you by going through the figures. You will see that we have been able to add a very substantial amount to the reserve fund, namely, £4,500, which now brings it up to £71,000, ready for any emergency. But you must bear in mind that although there is that sum to the credit of the reserve fund we still have to pay a portion of the cost of the cable that we contracted for, and which is being paid off every year. The amount still to be paid is £21,000 odds, so that you may reckon that our reserve fund is actually £50,000. We hope that the cable will continue to work as it has hitherto done, and in that case we shall be free from this annual payment in the course of five or six years. The report is so favourable that I shall not detain you longer with more explanations, but simply move, "That the report and accounts now submitted be received and adopted."

Mr. LOW seconded the motion.

Mr. SQUIRE wished to know the amount that was annually paid out of the revenue towards wiping off the debt on the cable.

The CHAIRMAN replied that it constituted an annual charge of £3,750.

Mr. GRIFFITH expressed his great satisfaction with the favourable nature of the report and accounts. He desired, however, to suggest whether it would not be better to invest the reserve fund in stock of a more permanent character than those in which it was now locked up. He further wished to know whether the Spanish agency could not be dispensed with.

The CHAIRMAN, in reply, said that, with regard to the latter question, the Company, according to the terms of its concession, was bound to have an agent at Madrid. It was not, he might say, absolutely necessary, but still it was an understood thing, and, moreover, the Directors found that it was very useful to have an agency there. For example, the other day, when there was some talk about a cable being laid to the Antilles by a Spanish company, their agent in Madrid kept them posted up in all that took place on the subject. Therefore, he was sorry to say that the Directors would not be able to do away with the item of £200 which the agency cost them. As regarded their investments, he could only say that the whole of them were perfectly safe. Unfortunately, every now and then there was a slight diminution in the rate of interest given for their deposits at the bank, and it might be possible that in a year or two money would become so cheapened that it would be safer to invest the whole of their reserve in Consols instead of as now. But at present he thought it was advisable that they should get as much as they could out of their £71,000. As to the amount that they would require the reserve to reach, they had put the figure at £100,000, but whether they would stick at that amount he would not like to say. Cables did not last for ever, and the time might come when they would have to lay an extra cable, which would cost them between £40,000 and £50,000. Therefore their reserve should be employed not only to lay any new cable that might be required, but to give security to the shareholders and maintain their dividend of 8 per cent., which he hoped would continue for many years to come.

The motion was then unanimously agreed to.

The CHAIRMAN: The next resolution is, "That the following dividends be now declared for the half-year on the shares of the Company, viz, at the rate of 10 per cent. per annum, subject to income-tax, on the preference shares, and at the rate of 8 per cent. per annum, free of income-tax, on the ordinary shares, payable on and after to-morrow."

Mr. NEIL BANNATYNE: I second that.

The motion was put, and carried unanimously.

On the motion of Mr. Low, seconded by Mr. GREENWOOD, Mr. J. de Mancha was re-elected a Director of the Company.

The auditor, Mr. Thomas Greenwood, was also reappointed.

Mr. GRIFFITH proposed a vote of thanks to the Chairman and Directors, whose services to the Company he highly eulogised.

Mr. SQUIRE having seconded the motion, it was cordially passed.

The CHAIRMAN, in reply, expressed the thanks of himself and his colleagues, and said he wished they might be able to improve upon the present dividend. At any rate they hoped they would never have occasion to come before the shareholders with a smaller one than they did now. Their endeavour had been to do their work satisfactorily. It was not a very hard task that they had to perform, and they were so well assisted by their secretary and by their *employés* that they got through it with a great deal of satisfaction, and whilst he would again thank the shareholders for their approbation, he would like to move a vote of thanks to Mr. Scott and to their *employés* abroad for the efficient manner in which they performed their duties.

The motion, having been seconded by Mr. Low, was carried unanimously.

The SECRETARY briefly responded, and the proceedings terminated.

Globe Telegraph and Trust Company (Limited).

The fourteenth ordinary general meeting of this Company was held on Thursday last at Winchester House, 50, Old Broad-street, under the presidency of John Pender, Esq.

The SECRETARY (Mr. Wm. Payton) read the notice convening the meeting, and the minutes of the last meeting, which were approved by the present meeting and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen—I will, as usual, make some remarks upon the business of last year, and give you all the information that we possess as to the working of the Company's affairs. Our accounts show a diminished dividend this year, resulting from the continuance of the 6d. tariff for the Atlantic cable companies in which we hold largely stocks and shares. In 1885 we received from this source £38,467, when we paid 4½ per cent. on our ordinary shares; in 1886 we received from this source £20,046, when we paid 3⅝ per cent.; in the financial year just ended we have only received £6,685, and our dividend is 2⅜ per cent. From the Eastern and the Eastern Extension Companies we received £92,029 in 1886, while in the present year we have had but £82,028. The diminution in the dividends above mentioned accounts generally for the falling off in the dividend on our ordinary shares, the diminiuton in the case of the two last named companies arising from the reduction of the tariffs forced on them by the Berlin Conference. This Company is the barometer of telegraph companies generally. It is low now, but I am sanguine that we shall see a change before long. The average dividend on the ordinary shares during the last 14 years of our existence has been a little over 4¼ per cent., and our preference dividend has, of course, always been maintained at 6 per cent., or an average on both classes of shares of over 5¼ per cent. You observe in the report what is said about the Direct Spanish Company. We have received the accumulated dividend of £2. 10s. a share, or something like £1,500, and this has been carried to our revenue account. The capital of that company was reduced by order of the High Court of Chancery to one-half its nomial value, and we look to steady dividends in future from that direction. The German Union Company are earning a fair dividend of 6 per cent.; the Indo-European Company are returning something like 11¼ per cent. on our purchase price; the London Platino Company are doing better; and the Construction Company paid their usual dividend of 20 per cent. I may mention as evidence of the public appreciation of the utility of the Globe Company that while the market value of the Globe holding is about 3¼ millions sterling the market value of the Globe shares issued against them is about three and a half millions, or 4 per cent. higher. I have shown you exactly the reason of the fall in our dividend—that fall mainly arising from the sixpenny tariff that is still in force with the Atlantic companies in which we are interested. You may naturally ask me if I can give you any information on the war of rates. All the information I can give you is this—that I believe parties on the other side who are largely interested in the land lines in America, and who are also interested in the submarine system, have this thing in hand very much at this moment. What the result may be it is difficult for anyone to say. I do not know that they themselves know, excepting that they are fully aware that, although the present sixpenny rate is developing the traffic steadily and largely, it is very doubtful if that rate will ever pay a large dividend. But I would ask you, as I have asked all those who are interested in Atlantic cables, to be patient. I do believe that the men of business connected with the system, even on the other side, realise the fact that the present business is bad, and as they have it in

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sonally, and on behalf of my colleagues, not to give us a half confidence. We are doing all we can. We are endeavouring to economise in every way, and we hope the continuance of our policy will enable us to pay you, if not a large dividend, at all events a satisfactory one. With these observations I leave the matter in your hands, and I beg to move "That the report of the Directors and the accompanying statement of accounts to the 30th June, 1887, submitted to this meeting, be, and the same are hereby, received and adopted."

The Marquis of TWEEDDALE formally seconded the motion.

Mr. THOMAS SMITH (York) said he would support the adoption of part of the report, but he could not approve of the whole of it. He agreed with the Chairman's remarks as to the 6d. tariff; and the improvement in the traffics compared with the corresponding period of last year was very encouraging, and showed, to his mind, that the 6d. rate was an increasing success. For four months of the corresponding period of 1886 the 1s 8d. tariff was in force, as against 6d. in the whole of the past half year. The December half year they always considered, as the Chairman had said, the better half year, and in that half year they brought forward a balance of £2,423, leaving the net takings for the six months £87,384, compared with £100,534 in the six months now under review—to the 30th ult. In making that comparison, it must be remembered that they brought forward not a farthing in the half year just closed. After what the Chairman had said, he thought they might look forward with confidence to the coming half year, the best half of the year. He believed that they would consider with him that the sixpenny rate was progressing very satisfactorily, and that they had nothing to do but to sit still and work at it. In his opinion the future policy of the Company must be based on the 6d. tariff. Let them give it two or three years' trial. They would suffer from the want of dividend during that period; but he was quite willing, though a large shareholder, to forego his dividend for the present—that was, if the Directors would be fair towards them and divide what the Company earned. He did not agree with the Directors' policy as regarded the third paragraph of the report. At the last meeting the Chairman asked the shareholders for their patience, forbearance, and support, and he (the speaker) thought they had granted that request right loyally. Taking that into consideration, and the fact that nothing had been brought into last half year's account, he thought the Directors should have made the dividend on the ordinary stock 10s. per cent. and on the preferred stock £1 per cent. After the shareholders had suffered as they had, the Directors ought to meet them in the most liberal way, instead of proposing to carry forward a balance to the next half year of 50 per cent. of the net earnings of the last six months. Such a proposal he regarded as preposterous. And what were they carrying it forward for, seeing that they had £84,500 uninvested? He did not think it could be said that there was any shortness of money, with £84,000 doing nothing, and for which they had received £165 as interest. At the meeting last February, too, they were promised a detailed list of the investments.

The CHAIRMAN: Have you not got it in the report?

Mr. SMITH said he did not consider it a detailed statement, such as that given by Mr. Pender in the case of the Globe Telegraph Company. There was an item of £13,000 given as "other securities." Was that a detailed statement? Such a statement would only have to be done once, and it would really cause practically no trouble. He was glad to hear the Chairman speak about economy, but he could find no evidence of it in the accounts. In conclusion he moved as an amendment, "That the report be adopted, with the exception of the part of paragraph 3 which states that £18,323. 6s. 8d. be carried forward, and in lieu thereof that a dividend of 10s. per cent. be paid on the ordinary stock and 20s. per cent. on the preferred stock."

Mr. C. E. DAVISON seconded the amendment. The Directors must be aware that for a long time the shareholders had suffered from the want of dividends, and it was only right that, instead of £17,500 being now distributed, £35,000 should be divided among them, which would be the effect of carrying Mr. Smith's amendment, and which he urged the Directors to support.

The CHAIRMAN: I am not now going to answer Mr. Smith's observations, but I wish to say a few words about his amendment, as to which it would be perfectly useless and a waste of your time to have any discussion. I am precluded from putting it to the meeting by the Articles of Association. The shareholders cannot declare any larger dividend than that recommended by the Directors, and I should be forfeiting all claims to your confidence, and should be violating my duty if I put this amendment. I have the greatest possible sympathy with the shareholders. The fact is that this is an interim dividend. We retain this fund in our hands, but it is only an estimated surplus. It should be remembered that we are engaged in litigation with the French Company, and that we have at this moment a very expensive repairing expedition going out. We may require money for that, and at all events we have to the best of our judgment done what we thought was for the true interests of the shareholders in declaring this interim dividend, with the prospect that during the year we shall be able to give them something more.

Mr. WILLIAM ABBOTT said he had been very pleased to find Mr. Smith—a gentleman whose remarks at the meetings were deserving of every respect—so strong an advocate of supporting the Board in the policy they had adopted respecting the 6d. tariff. He himself at the last meeting had not agreed with that policy, because he had thought it desirable that some arrangement should be made by which the tariff should be raised to 1s. He had, however, completely altered his opinion, for the 6d. tariff did not suit their competitors at all. He thought they should continue the tariff, and wait and see the result. At that meeting he was particularly desirous that they should give a unanimous support to the Directors. He did not think the detailed information respecting the cost of the securities of the renewal fund was necessary, and what he himself admired about the report was its simplicity. They had securities valued at £882,000, with £84,000 uninvested. He thought it would be very satisfactory if they could be told whether the present market price of the £882,000 was in excess of the actual cost price of the securities. He begged the Directors to invest nothing further in the Canadian Pacific Railway Company.

The CHAIRMAN: It is a first mortgage.

Mr. ABBOTT said he had no faith in the Canadian Pacific Company. He was glad to see the legal expenses so small, and astonished to see Mr. Burt looking so well notwithstanding. He regretted that Mr. Smith had spoiled his statement by the amendment which he had proposed, and he thought that they should on that occasion show their competitors that they were "full of fight." He would be sorry to see distributed the £18,000 which the Directors in the report had suggested should be carried forward.

Mr. GRIFFITH said he considered that the argument adduced by Mr. Smith in support of his amendment was unanswerable. He maintained that the £84,000 referred to ought to have been invested to produce 3 per cent. at least. He entirely agreed with Mr. Smith. As to the amendment, the Chairman took a very restricted view of what the Articles of Association provided. They could put the amendment in this way—that they would not receive the report, that they would send it back, and that unless the Directors would declare the extra dividend which Mr. Smith proposed, they would not pass the report. Remembering the additional expense involved by the increased work that had to be done with a sixpenny tariff, he reckoned that they would have to earn four times the amount they had earned with the 1s. 8d. tariff before they could even attain the wretched position they were in with the higher tariff. He supported the amendment. The time had come when the Articles of Association should be altered.

Mr. JOHN NEWTON contended that the revenue earned by the reserve fund ought to be added to the general revenue of the Company, and not put to the fund.

Mr. HERBERT SMITH (Gray's Inn) maintained that it was unnecessary to carry forward the sum of £18 000 as proposed in the report.

Mr. HUMPHREYS wished to know why it was that the £84,000 had not been invested. He viewed the report in an unfavourable light, and he believed that the reduction in the tariff from 1s. 8d. to 6d. was an act of temper, the whole circumstances of the case not having been taken into consideration.

The CHAIRMAN: I regret very much that we have not the admiration for our report of the gentleman who has just sat down, but I think he takes rather a prejudiced view of the conduct of the Board, because he says that the adoption of a 6d. tariff was an act of temper. I can only say that so far from being an act of temper, when one commits an act under the influence of temper one acts hastily, but I never, since I have been on the Board—now for a good many years—remember any act that was taken with greater deliberation, more circumspection, and more consideration of all the circumstances of the case. The gentleman has also said that the rate would never rise beyond 6d. That view is certainly not derived from any observation I have made, for I guarded myself most carefully in saying that it was a low rate we went in for with a certain object, and that we can never bind ourselves to any particular rate as one we would arrive at. So much for Mr. Humphries. I now proceed to answer as well as I can the different observations made. Mr. Smith took occasion to animadvert on the amount of the dividend, and said it might have been 10s. per cent. He is quite right. It might have been 10s. per cent; but had we declared a 10s. dividend we should have divided up very closely on a balance which was only an estimated balance. I wish the stockholders to remember that this is not the final dividend. This is merely an interim dividend. You will, I hope, receive another and I trust a larger dividend next quarter.

A SHAREHOLDER: You told us that six months ago.

The CHAIRMAN: I do not pretend to infallibility, and if I did venture to prophesy I think it probable that I might have been incorrect. But still I had not the same ground then as I have now, because we have now, so far as an estimate goes, the money in hand, and we shall pay up as closely as possible in the next half year. Mr. Smith and some other gentlemen made some observations about the uninvested balance of the reserve fund. That balance is a sum which is probably not yet paid. Another portion of it is a sum which we shall have to pay in the course of a few days for the expense of the repairs; and now I put it to any of those gentlemen—I ask Mr. Abbott, as a practical man, does he think it would be wise for us as directors to invest money, incurring the expense of stamps and brokerage, which we should have to pay in two or three months?

Mr. ABBOTT: You must pay the broker.

The CHAIRMAN: We have sent out 300 miles of cable, which has to be paid for. It is really to save the money of the Company that we do not invest this sum. Then there is a small amount of £13 000 of which Mr. Smith made a great deal in point of argument. I wonder if Mr. Smith has ever read such a thing as the account of a charitable subscription, where a number of small sums are put down under one total. This £13,000 is put down here on the same principle. They are small investments not worth fully mentioning; but if Mr. Smith has the least curiosity he really only has to go to the offices of the Company and Mr. Wells will tell him.

Mr. SMITH said that he wanted the information not merely for himself, but for the benefit of all the shareholders. They could not all go to the offices for the information.

The CHAIRMAN: I think if you get the information respecting £382,000 it is taking rather a microscopic view of things to want the details about £13,000. Mr. Abbott asked what is the total value of the investments to-day. As nearly as we can calculate, taking the middle value, the securities are worth about £25,000 more than they cost us. As to the Canadian Pacific Railway, it was very good advice—[Mr. ABBOTT: It was only a hint]—given by a stockbroker to an investor who had come to consult him; but I do not think the Canadian Pacific Compnay would like such

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advice to be given and discussed at a public meeting. With reference to the revenue from the renewal fund, the whole question of that fund was the subject of an arrangement that was entered into between the Board and the committee headed by Mr. Smith. The result of that arrangement was that no further addition to the renewal fund, except the interest derived from the investments forming the fund, should be added to it after it had reached to £1,000,000. It is not £1,000,000 yet, although, to use a common phrase, it is "within measurable distance" of that amount. When we get to our million we will consider how the interest earned by the investments of the fund shall be disposed of with due regard to the interests of the shareholders. The only other observation I am led to make is with reference to something that was said by Mr. Herbert Smith about this £18,000. He said it is not going to be paid in dividends; but what I said was that we do not declare it now, because it is only an estimate. We mean, however, hereafter to apply it to the shareholders' benefit just as much as if we gave it now. I am sorry that we are obliged to reject the amendment of Mr. Smith, but I cannot put it, and I hope that he will withdraw it. [Voices: "Withdraw!"]

Mr. SMITH said he would take the Chairman's advice under the promise which had been made. He again asked that a detailed statement might be made in the accounts as to the cost of the investments of the renewal fund. Let the Directors take as their guide the information that was given by the Globe Company.

The CHAIRMAN said he thought he had in a great measure supplied the information asked for in stating what the price of the securities was at the present time.

The motion was then put in the usual way, and declared to be carried.

Mr. ABBOTT proposed, and Mr. THOMAS SMITH seconded, a vote of thanks to the Chairman and Directors. This having been unanimously agreed to,

The CHAIRMAN said: I am exceedingly obliged to you for your vote of thanks, which has been so constantly passed to us. I am particularly obliged on the present occasion, because I feel that there is a great deal which the shareholders have to bear, and which the Directors would not impose on them if they could help it.

The proceedings then terminated.

Cuba Submarine Telegraph Company.

The thirty-second ordinary general meeting of the shareholders in this Company was held on Wednesday last, at the Company's offices, 61, Old Broad-street, E.C., under the presidency of Mr. Joaquin de Mancha.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the Directors' report and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, I have again the pleasure of meeting you with a very favourable report, and I think that on the face of it very little need be said. Our business seems to go on satisfactorily. Our income has increased a little, although not so much as I should have liked, because we have carried a great many more messages in this half year than we did in the corresponding six months. Those extra messages amount to over 2,000, and the increase in our receipts has been only £547. People are getting so clever in the matter of telegraphy now, that the messages do not amount to so much as they did before. The report is so full that I need not detain you by going through the figures. You will see that we have been able to add a very substantial amount to the reserve fund, namely, £4,500, which now brings it up to £71.000, ready for any emergency. But you must bear in mind that although there is that sum to the credit of the reserve fund we still have to pay a portion of the cost of the cable that we contracted for, and which is being paid off every year. The amount still to be paid is £21,000 odds, so that you may reckon that our reserve fund is actually £50,000. We hope that the cable will continue to work as it has hitherto done, and in that case we shall be free from this annual payment in the course of five or six years. The report is so favourable that I shall not detain you longer with more explanations, but simply move, "That the report and accounts now submitted be received and adopted."

Mr. LOW seconded the motion.

Mr. SQUIRE wished to know the amount that was annually paid out of the revenue towards wiping off the debt on the cable.

The CHAIRMAN replied that it constituted an annual charge of £3,750.

Mr. GRIFFITH expressed his great satisfaction with the favourable nature of the report and accounts. He desired, however, to suggest whether it would not be better to invest the reserve fund in stock of a more permanent character than those in which it was now locked up. He further wished to know whether the Spanish agency could not be dispensed with.

The CHAIRMAN, in reply, said that, with regard to the latter question, the Company, according to the terms of its concession, was bound to have an agent at Madrid. It was not, he might say, absolutely necessary, but still it was an understood thing, and, moreover, the Directors found that it was very useful to have an agency there. For example, the other day, when there was some talk about a cable being laid to the Antilles by a Spanish company, their agent in Madrid kept them posted up in all that took place on the subject. Therefore, he was sorry to say that the Directors would not be able to do away with the item of £200 which the agency cost them. As regarded their investments, he could only say that the whole of them were perfectly safe. Unfortunately, every now and then there was a slight diminution in the rate of interest given for their deposits at the bank, and it might be possible that in a year or two money would become so cheapened that it would be safer to invest the whole of their reserve in Consols instead of as now. But at present he thought it was advisable that they should get as much as they could out of their £71,000. As to the amount that they would require the reserve to reach, they had put the figure at £100,000, but whether they would stick at that amount he would not like to say. Cables did not last for ever, and the time might come when they would have to lay an extra cable, which would cost them between £40,000 and £50,000. Therefore their reserve should be employed not only to lay any new cable that might be required, but to give security to the shareholders and maintain their dividend of 8 per cent., which he hoped would continue for many years to come.

The motion was then unanimously agreed to.

The CHAIRMAN: The next resolution is, "That the following dividends be now declared for the half-year on the shares of the Company, viz, at the rate of 10 per cent. per annum, subject to income-tax, on the preference shares, and at the rate of 8 per cent. per annum, free of income-tax, on the ordinary shares, payable on and after to-morrow."

Mr. NEIL BANNATYNE: I second that

The motion was put, and carried unanimously.

On the motion of Mr. LOW, seconded by Mr. GREENWOOD, Mr. J. de Mancha was re-elected a Director of the Company.

The auditor, Mr. Thomas Greenwood, was also reappointed.

Mr. GRIFFITH proposed a vote of thanks to the Chairman and Directors, whose services to the Company he highly eulogised.

Mr. SQUIRE having seconded the motion, it was cordially passed.

The CHAIRMAN, in reply, expressed the thanks of himself and his colleagues, and said he wished they might be able to improve upon the present dividend. At any rate they hoped they would never have occasion to come before the shareholders with a smaller one than they did now. Their endeavour had been to do their work satisfactorily. It was not a very hard task that they had to perform, and they were so well assisted by their secretary and by their *employés* that they got through it with a great deal of satisfaction, and whilst he would again thank the shareholders for their approbation, he would like to move a vote of thanks to Mr. Scott and to their *employés* abroad for the efficient manner in which they performed their duties.

The motion, having been seconded by Mr. LOW, was carried unanimously.

The SECRETARY briefly responded, and the proceedings terminated.

Globe Telegraph and Trust Company (Limited).

The fourteenth ordinary general meeting of this Company was held on Thursday last at Winchester House, 50, Old Broad-street, under the presidency of John Pender, Esq.

The SECRETARY (Mr. Wm. Payton) read the notice convening the meeting, and the minutes of the last meeting, which were approved by the present meeting and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen—I will, as usual, make some remarks upon the business of last year, and give you all the information that we possess as to the working of the Company's affairs. Our accounts show a diminished dividend this year, resulting from the continuance of the 6d. tariff for the Atlantic cable companies in which we hold largely stocks and shares. In 1885 we received from this source £38,467, when we paid 4½ per cent. on our ordinary shares; in 1886 we received from this source £20,046, when we paid 3⅝ per cent.; in the financial year just ended we have only received £6,685, and our dividend is 2⅜ per cent. From the Eastern and the Eastern Extension Companies we received £92,029 in 1886, while in the present year we have had but £82,028. The diminution in the dividends above mentioned accounts generally for the falling off in the dividend on our ordinary shares, the diminiuton in the case of the two last named companies arising from the reduction of the tariffs forced on them by the Berlin Conference. This Company is the barometer of telegraph companies generally. It is low now, but I am sanguine that we shall see a change before long. The average dividend on the ordinary shares during the last 14 years of our existence has been a little over 4¼ per cent., and our preference dividend has, of course, always been maintained at 6 per cent., or an average on both classes of shares of over 5¼ per cent. You observe in the report what is said about the Direct Spanish Company. We have received the accumulated dividend of £2. 10s. a share, or something like £1,500, and this has been carried to our revenue account. The capital of that company was reduced by order of the High Court of Chancery to one-half its nomial value, and we look to steady dividends in future from that direction. The German Union Company are earning a fair dividend of 6 per cent.; the Indo-European Company are returning something like 11¼ per cent. on our purchase price; the London Platino Company are doing better; and the Construction Company paid their usual dividend of 20 per cent. I may mention as evidence of the public appreciation of the utility of the Globe Company that while the market value of the Globe holding is about 3¼ millions sterling the market value of the Globe shares issued against them is about three and a half millions, or 4 per cent. higher. I have shown you exactly the reason of the fall in our dividend—that fall mainly arising from the sixpenny tariff that is still in force with the Atlantic companies in which we are interested. You may naturally ask me if I can give you any information on the war of rates. All the information I can give you is this—that I believe parties on the other side who are largely interested in the land lines in America, and who are also interested in the submarine system, have this thing in hand very much at this moment. What the result may be it is difficult for anyone to say. I do not know that they themselves know, excepting that they are fully aware that, although the present sixpenny rate is developing the traffic steadily and largely, it is very doubtful if that rate will ever pay a large dividend. But I would ask you, as I have asked all those who are interested in Atlantic cables, to be patient. I do believe that the men of business connected with the system, even on the other side, realise the fact that the present business is bad, and as they have it in

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their power to make the alteration more than we have on this side, I am hopeful that before many months pass over we shall see the war of rates at an end. At all events, the companies here are doing their best, and I think we are bound to support them, because, after all, we are very large shareholders in the Atlantic and other companies. We are bound to support them in this sense, that there has been a great deal said about low rates enormously increasing the traffic and consequently the revenue. I believe that low rates must eventually increase the revenue, but the cable system is a peculiar system. We can only carry a certain number of words on a cable, and if the 6d. rate does not pay the cable when it is full, of course we cannot expect any extension of traffic will give us any increased return. It would require more cables, and therefore more capital would be required to lay those cables. However, I think it is right, now that we are dealing with a sixpenny tariff, that we should exhaust it to the fullest point, and that a few months more will not be badly spent in testing how far this sixpenny tariff is going to be developed. The other fall which I referred to was the lowering of the rates arising from what was done at the Berlin Conference. When I last had the pleasure of addressing you twelve months ago we had just begun the lower rates which were then forced upon us. Those lower rates involved something like a loss of £100,000. For the first few months after the rates were reduced we saw very little response, but I am glad to say that we are almost day by day recouping the loss, and by the time I meet you next year I believe I shall be able to say that that loss has been recouped. That is one of the bright sides of the picture, and if I can add at the same time that we have got a reasonable rate for our Atlantic system, with our vast interest in that system, we shall be able to show you a very much better dividend than we can show you to-day. I have given you probably all the information I can give you excepting this, that this Globe Company holds interests in every submarine system—(A Voice: Except the Commercial)—except the Commercial, which is a private company; but I would not be astonished if before very long you see the Commercial Company's interest more or less connected with the Globe interest. What, however, I was going to say was this—that the growth of submarine telegraphs is really enormous, and they are conferring benefits not only at home but throughout our Colonies, and, in fact, in every part of the civilised world. As I said at a public gathering last night, the mileage of submarine cables within the last twenty years has risen from about 2,000 to 115,000 miles. That shows that the system of submarine telegraphy is becoming a vast interest, and as the Globe Company will more or less be dependent upon that system, and as that system is growing, I have no doubt that the Globe Company must eventually benefit through that growth. I think that that is pretty much all that I have to tell you. The different cables in which we are interested are all working fairly well. As to those of our opponents—the other Atlantic cables—two of them are interrupted, and that fact contributes largely to the traffic of those that remain. As, however, I have said, the 6d. rate, while doing good in one direction, I am afraid does not do much good towards paying a dividend. I now beg to move "That the report and accounts for the year ended 18th July, 1887, submitted to this meeting, be and they are hereby received and adopted, and that dividends be now declared payable on and after this day as follows—namely, 3s. per share on the preference shares, making with previous quarterly dividends a total dividend of 6 per cent. on the preference shares, less income-tax, and of 2s. 3d. per share net on the ordinary shares, making with previous distributions a total payment for the same period of £2. 7s. 6d. per cent. per annum on the ordinary shares."

Sir DANIEL GOOCH, Bart., seconded the motion.

Mr. CROOKS asked whether it would not be advisable to get rid of a bad bargain, and dispose of the interest held by them in the Atlantic cables to the amount of over £1,000,000. Why should they continue to carry a heavy burden like that?

The CHAIRMAN: You would not sell stock at a time when it is depressed.

Mr. CROOKS: If I have a bad tenant I do not see why I should keep him. I should get rid of him, and obtain a tenant who would pay me.

The CHAIRMAN: But always take your goods to the best market. You could not take them to a worse market than at the present time, and, more than that, I do not think you could get a customer.

Mr. CROOKS said that if he had invested £40,000 in anything which brought him no return, he would be disposed to sell the investment for half its value, and invest the £20,000 and get some interest on the lower amount.

The CHAIRMAN: I think you must trust your Directors in the management of this business. We have told you exactly the circumstances which have arisen to reduce the Atlantic tariff from 2s. to 6d. I have told you very distinctly, I think, that the 6d. rate is not likely to continue very much longer, and if we revert to a higher rate we shall be able to pay a very much higher dividend. Therefore, with such a prospect before us, I think it would be very foolish indeed if we parted with a single pound's worth of our property.

Mr. CROOKS pointed out that the shareholders, under the existing state of things, had been heavy sufferers for the last eighteen months or two years.

The CHAIRMAN: It is not quite a bed of roses for Directors when a war of rates is going on.

Mr. CROOKS: But the poor shareholders have to suffer.

The CHAIRMAN: It so happens that in this case we are poor shareholders, too. There is nothing so unpleasant to the Directors as to come before you and propose such a poor dividend. In answer to Mr. John Brown the Chairman added: I have not seen the paragraph that you speak of in *The Times* of this morning, but I think I know pretty well what that paragraph must be. I think I have stated to you that there are negotiations going on which I hope will result in making a change for the better. I am not prepared—because I do not know myself—to state what the negotiations are, but I mentioned, I think, that there are men of business largely interested in these negotiations who know at the present moment that it is a bad state of things that exists, and that the sooner they improve it the better. I am therefore hopeful that before a very long period we shall get out of these bad rates.

A SHAREHOLDER said that on the previous day Lord Monck, at the meeting of the Anglo-American Telegraph Company, had stated that there were no negotiations going on.

The CHAIRMAN: I think you must have misunderstood him, for I was present. What Lord Monck said was, what I have said, that there are negotiations going on in America and not in England, and therefore that we do not know what is the nature of the negotiations. There are large land lines in America that belong to the Western Union Company, and there is a competing system, and when this question is settled with regard to the land lines there will be a settlement also with respect to the submarine cable system.

Mr. MASON said that the paragraph in *The Times* of that day, to which reference had been made, had been cabled from Philadelphia on the previous day, and was as follows:—"The negotiations between the rival Atlantic cable companies are reported to be making progress. The result may be a termination of the 'cable war,' and the advancing of rates to 40c., and probably even 60c., per word."

The CHAIRMAN: All I can say in regard to that paragraph and newspaper paragraphs generally is that until I know absolutely myself I do not pay very much attention to newspaper paragraphs. I am receiving every day telegrams from America as to what is said in one paper and what is said in another, both at Boston, Philadelphia, and New York. I sometimes ask whether there is any truth in these statements, and generally the answer is "No," or, like the other day, "Very exaggerated."

Mr. JOHN NEWTON asked what was being done with respect to the French Cable Company. He thought the shareholders would be very glad if the Directors would increase the interest of the Company in the French Company, so that they could then teach that Company a lesson in fair play and justice, and go to their meetings with sufficient influence to command the position. The Globe Company ought to be very much more powerful than it was to stop competition. One mistake they had made was in having gone into business without having sufficient capital to control the telegraph systems of the world. They could, he held, have occupied that position if the original intention had been carried out. He would be glad to hear that the Directors intended to get control of the French Company, which had broken its contract with the English Companies. On the question of the cable war, he was perfectly satisfied that negotiations were going on, and with the support of the Directors of the English Companies. He hoped that no settlement would be made unless it settled for some time the question of what was a paying rate.

The CHAIRMAN: Hear, hear.

Mr. NEWTON: If the 6d. rate were continued for a few months more, probably they would be able to say, and to say with authority, what was the exact result.

The CHAIRMAN, in reply, said: I think Mr. Newton has made one point, and that point is that we should now, as far as it is within human power to do it, make a permanent settlement of the rate that will give a fair return to the shareholders. I think it is for that reason that I ask you to forbear a little longer. The question of rates should be settled, and the rate should be such as would give a fair return to the shareholders, full justice to those who use the telegraph, and no encouragement whatever to competitors to bring in fresh cables. That is the policy we have before us, and that, I hope, we shall keep steadily in sight during these negotiations.

A SHAREHOLDER asked what rate the Chairman thought would give a fair return to the shareholders.

The CHAIRMAN: You must not ask me questions of that kind.

A SHAREHOLDER: What does the Commercial Company charge?

The CHAIRMAN: Their rate is 1s. They have gone on at 1s. They made a bargain that all those that stood by them and paid 1s. would, if they went above 1s. 8d., be refunded the difference between 1s. and 6d. That has gone on for a considerable time. When they started at 1s. 8d., which was a reduction of 4d. on the then existing tariff, they got a very large proportion of the traffic from us. I think, however, at the present time they are in the most unsatisfactory position, and I believe they will be quite as anxious as we are to arrive at an arrangement, though I do not say that we are particularly anxious on the point.

Mr. NEWTON asked whether the Directors saw their way to increase their interest in the French Company.

The CHAIRMAN: The French Company is in a very peculiar position as to the shares. If we bought a large number of the shares we should not know how to use them. We should have to put them into the hands of a variety of people. That company is in a very unfortunate position at the present time. Their cable is broken. They are out of the pool—at least, they say they are out, and they are now in a sort of helpless condition. The shares of the French Company within the last three or four months have fallen from something like 110fr. to 80 or 90fr., and the fall is still, I hear, going on. I think that our position is very fortunate compared with theirs.

The resolution was then put and carried.

On the motion of the CHAIRMAN, seconded by the Marquis of TWEEDDALE, Mr. William Ford and Sir Daniel Gooch, Bart., were re-elected to their seats at the Board. Subsequently, on the motion of Mr. JACKSON, seconded by Mr. STOCKDALE, Mr. John G. Griffiths, F.C.A., and Mr. William Griffith, B.A., were re-elected auditors of the Company.

Mr. GRIFFITH then proposed a vote of thanks to the Chairman and Directors. He thought the shareholders were very fortunate in having as Chairman of the Company a gentleman whom he regarded as the chief authority on telegraph questions. In times past the shareholders had

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received good dividends from the Company, and though at present the dividend was not so large as usual, the reason which had been given by the Chairman must be looked upon as sound and satisfactory. The Chairman had given the shareholders all the information they had required, and most valuable information.

Mr. JACKSON seconded the motion, which was carried unanimously.

The CHAIRMAN: Gentlemen, on behalf of my colleagues and myself, I return you sincere thanks for the renewed expression of your confidence in us. We are watching very closely all that is going on in the Atlantic cable system at the present time, and, as we are very large shareholders in all the companies, you may depend that if we saw anything going on that was contrary to your interests we should be the first to endeavour to stop it. As long as we sit on this side of the table it will be our interest to protect your interests, and to pay you the best dividend we can.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 27.		BUSINESS DONE WEEK ENDING JULY 27. Highest.	Lowest.
Anglo-American	37,	38	37½	—
Do. Preferred	60,	61	60½	60
Do. Deferred	14½,	15½	14 13-16	—
Brazilian Submarine	11⅛,	11⅜	11⅜	11 1-16
Cuba	12½,	12¾	12⅝	12½
Do. Preference	18,	19	—	—
Direct Spanish	2⅞,	3	—	—
Do. Preference	7⅞,	8½	—	—
Direct United States Cable	9,	9½	9 1-16	9
Eastern Telegraph	11,	11½	11 5-16	11⅜
Do. 6 per Cent. Preference	14,	14½	14⅜	14½
Do. 5 per Cent. Debentures, 1899	107,	110	—	—
Eastern Extension	11⅜,	11⅝	11⅝	11 11-16 xd
German Union	10⅞,	11	10⅞	—
Globe Telegraph and Trust	5½,	5½	5 7-16	—
Do. Preference	13,	13½	13½	13
Great Northern	13½,	14	13⅞	—
Indo-European	35,	37	—	—
Reuter's	7½,	7¾	—	—
Submarine	180,	190	—	—
West India and Panama	⅝,	¾	¾	9-16
Do. 1st Preference	8¾,	9½	9	8½
Western Brazilian	8,	8½	—	—
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	104,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	¾	11-16
Oriental	½,	⅝	—	—
United Telephone	11⅞,	12½	12½	11⅞ xd

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	1⅞	1½
Do. (fully paid)	3,	4	—	—
Swan	1½,	1½	—	—
Maxim Weston	½,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	35,	36	36½	35½
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23⅞	23½

CITY NOTES, &c.

EASTERN TELEGRAPH COMPANY.—This company announce that they will, on and after the 2nd August, pay the Five per Cent. Debentures terminable on that day at the Banking House of Messrs. Glyn, Mills, Currie and Co, 67, Lombard-street, London, with the final coupon of £2. 10s. The debentures to be lodged at the bankers two clear days for examination before payment.

THE EASTERN EXTENSION, AUSTRALASIAN, AND CHINA TELEGRAPH COMPANY.—This company notify that the coupon on their Six per Cent. Debentures due August 1st will be paid after that date at the Consolidated Bank, 52, Threadneedle-street, E.C. The coupon must be left at the bank three clear days for examination.

NATIONAL TELEPHONE COMPANY.—The directors announce a dividend for the six months ending 30th June last at the rate of 6 per cent per annum on the first and second preference shares, and at the rate of 4 per cent. per annum on the ordinary shares, as against 3½ per cent. for the corresponding period last year. Of the remaining profits the sum of £1,500 is to be added to the reserve fund, and the balance of £214 carried forward. The unaccrued revenue carried forward to the credit of next account amounts to £49,525, as against £43,985 carried forward last year.

WOODHOUSE AND RAWSON.—It will be seen that the business of Messrs. Woodhouse and Rawson is to be turned into a limited company, with a capital of £200,000. The company is to acquire the business of this well known firm, the stock-in-trade, patents, shares in subsidiary companies, goodwill and other assets. It will be seen from the prospectus, which will be found in our advertising columns, that the founders practically stake the whole of their acquired position and profits upon the future of the Company, pledging the whole value of their patents, and all future improvements thereon, licenses, agencies, options, and goodwill, as a guarantee for the payment of a cumulative dividend at the rate of 10 per cent. per annum on the capital now offered for subscription. The arrangement with reference to the founders' shares is of great importance to the ordinary shareholders, as it permits the declaration and payment of dividends out of the sales of patents or licenses Messrs. Woodhouse and Rawson were one of the first firms to devote themselves specially to electrical work, are contractors to the Admiralty, War Office, Metropolitan Board of Works, the Royal Courts of Justice, and other public departments; they have also done a large amount of work for many well-known establishments, such as the Lancashire and Yorkshire Railway, Messrs. Guinness and Co., Messrs. James Shoolbred and Co., the Stock Exchange, &c., and have obtained numerous medals, certificates, &c., at the principal exhibitions. The business is to be taken over as a going concern, the management remaining exactly as it now stands, with the exception that Mr. F. L. Rawson will have coupled with him as managing director Mr. Hoster, the inventor of the postal stamping machine and the Garry-Hoster rifle, whose thorough knowledge of Continental business will be of great assistance in the foreign department, to which he has already been attending for some months past. The other directors besides Sir John Stokes are Mr. Kincaid, who will take charge of the electrical railway and tramway department, and Mr. Lambert, who was a partner in the firm of Humber and Co., the bicycle manufacturers, before he turned his business into a company. We trust the development of the company will continue as satisfactory in the future as the progress of the firm has in the past; and this is to be expected, especially as it will be under the same energetic management.

NEW COMPANIES REGISTERED.

CROYDON AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED). Registered by Edmund Dean, 37, Walbrook, E.C., with a capital of £20,000 in shares of £5 each. Object, to carry on the business of electric engineers and to supply the parish of Croydon with electric light, electric heat, and electric power.

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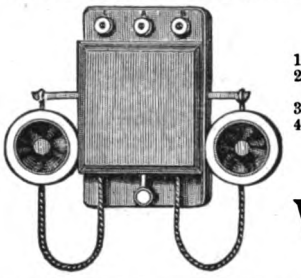
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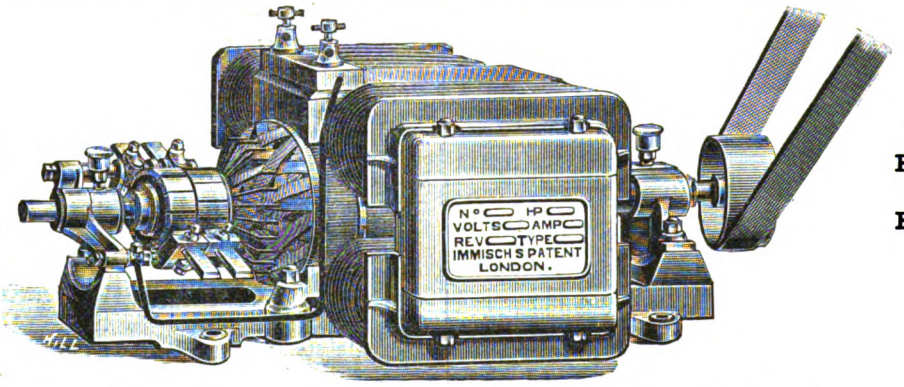
The Corporation are now prepared to supply and erect Electric Lighting Plant on the Purchase Hire System. Full particulars on application to the Secretary.

Highest Award for Electric Motors at the International Inventions Exhibition, London, 1885.



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NOTES.

BUCHAREST.—The Roumanian Government has announced the intention of undertaking the establishment of a telephone exchange at Bucharest.

EDISON AND SWAN V. SHIPPEY BROTHERS.—In another column will be found a report of the trial of the above action, which it will be seen resulted in favour of the plaintiffs.

THE INDIAN TELEGRAPH LINES.—The average time occupied in the transmission of messages from London to Calcutta by the lines of the Indo-European Telegraph Company is now one hour and ten minutes.

OPEN CONTRACT FOR ELECTRIC LIGHTING IN GERMANY.—On the 10th of September a contract will be made for lighting the town of Bremen by electricity. Particulars can be obtained from the Bureaukanzlei-fur-den, Zollanschloss, 219, Contrescaupe, Bremen.

ELECTRIC LIGHTING AT BURLINGTON HOUSE.—The Royal Society are about to extend the electric installation to a number of additional rooms. The work has been entrusted to Messrs. Drake and Gorham, by whom the installation was designed in the first instance.

PATENT LAW IN SWITZERLAND.—A poll recently taken in Switzerland has resulted in 190,000 votes for, and 56,000 against, an alteration in the law so as to give inventors better protection than they now enjoy. The Federal Government is thus empowered to enact a protecting law.

BRIGHTON.—A proposal is now before the Brighton Town Council to improve the lighting of the Marine Parade by the expenditure of an additional £563 per annum for gas. It is to be regretted that the Council do not see their way to place the contract in the hands of the local Electric Light Company.

THIRSK.—Proposals are invited for lighting the town of Thirsk with gas, oil, or electricity; seventy-two lights are required, to burn 1,100 hours per annum. Tenders are to be sent in by the 10th inst. to Mr. Z. Wright, clerk to the Inspectors, Thirsk, from whom also further particulars may be obtained.

THE BRUSSELS 1888 INTERNATIONAL EXHIBITION.—The electrical section of the International Exhibition, to be held next year at Brussels, is likely to prove one of very considerable interest and importance. In another column will be found the schedule under which prizes and medals will be awarded.

WIND-POWER.—The correspondent of a provincial contemporary is anxious to provide his house in the country with electric light. As only thirty lamps are required, he proposes to place a large vane or weathercock on the gable end of the house, and attach it to a vertical shaft from which the dynamo will be driven, storage cells being, of course, provided for use in calm weather.

NEW BOOKS.—We have received a copy of "Die Construction der Magnet-Elektrischen und Dynamo-Elektrischen Maschinen," by Von Gustav Glaser De Cew, edited by Dr. F. Auerbach, and published by A. Hartleben at Leipzig. The same publisher also sends us a copy of "Die Wirkungsgesetze der Dynamo-Elektrischen Maschinen," by Dr. F. Auerbach, of the University of Breslau.

ELECTRICAL COMMUNICATION WITH LIGHTSHIPS.—It is understood that the committee appointed by the Board of Trade to inquire into the desirability of electrical communication between light vessels and outlying lighthouses and the shore, with the special object of facilitating the saving of life at sea, have presented their report to the Board. It will be at once printed and circulated.

AN AMERICAN ELECTRIC LAUNCH.—The American electricians have been somewhat slow in turning their attention to the propulsion of boats by electricity, a circumstance which is no doubt accounted for by the fact that they have as yet but little experience with secondary batteries. An electric launch is, however, now being built in New York. The vessel will be 37ft. long, 7ft. wide, and 5ft. deep.

CHINESE TELEPHONES AND TELEGRAPHS.—The daily papers contain rumours to the effect that an American syndicate has obtained concessions from the Chinese Government giving it the exclusive right to construct railways, telegraph and telephone lines in certain parts of the Empire for a long period. We mentioned some weeks ago that certain American schemes were on foot in connection with the introduction of telephone lines in China.

MR. POPE ONCE MORE TO THE RESCUE.—Mr. Gilbert Pope has followed up the gallant achievement to which we referred last week by a feat of a similar character, in which, in the face of great difficulties, he succeeded in bringing ashore the body of a gentleman named Baldwin, an agent of the Duke of Devonshire, who had been seized with a fit whilst bathing at Lismore. Unfortunately, although rescued from the water, Mr. Baldwin did not recover, his death being attributed by the doctors to apoplexy.

NEW CABLE.—We understand that the new cable of the Eastern Telegraph Company has been successfully laid from Land's End to Lisbon and from Lisbon to Gibraltar, by the Telegraph Construction and Maintenance Company's ss. "Scotia." This cable is to be continued to Malta and Zante. It will be seen that this new cable provides a route for messages eastwards that touches at no foreign shore except Lisbon, and if any difficulty should arise with Portugal it will be easy to connect direct to Gibraltar.

TELEGRAPH INSULATORS.—In the House of Commons on Monday last Colonel Hughes-Hallett asked the Postmaster-General the price paid for the telegraph insulator manufactured by one particular firm, and what was the ordinary market value of this insulator? Mr. Raikes replied that the latest price paid by the Department for the insulator referred to in the first part of the hon. member's question is 10d., and as this kind of insulator is manufactured solely by the firm from whom they are obtained, 10d. may be taken as the ordinary market value.

NEW YORK.—The Thomson-Houston system is about to make a start in the City of New York, where hitherto the Brush and Weston systems have had a practical monopoly in arc lighting. Three companies have been formed to divide up New York City, and the orders given the Thomson-Houston Company for plant amount to no less than 2,250 lamps to start with, with prospective orders for double this number. The Edison Company have also just commenced to build a very large central incandescent lighting station further up the river, and it is rumoured that two more stations of the same size will shortly be undertaken in the same quarter.

ELECTRIC LIGHT FOR SEA FISHERIES.—Experiments are now being carried out in the Firth of Forth, on board the steamship "Tweeddale," on the use of the electric light for fishing at sea. The vessel has been fitted with an engine and dynamo, a 6,000 candle-power arc lamp, and some powerful incandescents, by Messrs. J. H. Perry and Co., of Liverpool. The incandescents were attached to the beam of the net, and

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sunk to a depth of 40 or 50 fathoms. But although the glass globes employed were ⅜in. in thickness it was found that they were not strong enough to withstand the pressure, and after a short time the glass invariably gave way. It is intended to renew the experiments next week with stronger globes.

SIGNALLING BY ELECTRIC LIGHT IN THE FRENCH NAVY.—M. J. Le Baron, electrical engineer to the firm of A. de Meritens and Co., writes us as follows:—"Whilst I was far from Paris you have published in your issue of June 10th, a note on naval signals transmitted at night by means of incandescent lamps. I only beg to add that lamps are supplied by small alternate current magneto-electric machine running by hand and made by Baron de Meritens, whose largest magneto-electric machines have just been installed at St. Catherine (Isle of Wight) and Isle of May lighthouses (*The Electrician*, December 17th and 24th, 1886). The Italian Navy is also provided with same apparatus supplied by our firm, A. de Meritens and Co."

HORSE v. ELECTRIC TRACTION ON TRAM LINES.—The following facts and figures are eloquent in proof of the need for reform in the present system of horse traction on tram lines:—During the last six months sixty horses belonging to the North Metropolitan Tramways Company have died or had to be killed, and 101 have been sold as no longer fit for the service. The first-named represent a loss to the company of £2,152, and the "cast" horses were disposed of at a sacrifice of £3,238, making a total of £5,390 loss on the half-year. Last year, in the corresponding period, it was £5,587. The company possess close upon 3,000 horses. It is clear that the Electric Traction Syndicate should receive the warmest encouragement and support from the R.S.P.C.A.

THE INSTITUTION OF MECHANICAL ENGINEERS.—In another column will be found an abstract of an interesting paper by Mr. D. A. Stevenson, on "The Electric Lighthouse at the Isle of May," read at one of the meetings of the Institution of Mechanical Engineers which are being held this week at Edinburgh. In our next issue we shall print a paper read by Mr. W. Geipel, "On the Position and Prospects of Electricity as Applied to Engineering," which will be found to contain a comprehensive survey of the whole field of electrical engineering. The only remaining paper dealing with electrical subjects was one on "Electrical Machine Tools," read by Mr. F. J. Rowan, and which gave an account of the apparatus devised by Mr. C. E. Rowan, which was fully illustrated and described in our issue of 3rd June.

WOODHOUSE AND RAWSON (LIMITED).—It should be a sign of progress when a larger capital is required in a business, and we take it that the necessity for a larger capital is the principal reason for turning a flourishing firm into a company. As is well known to our readers, Messrs. Woodhouse and Rawson commenced business in the early days of the electric lighting industry, and no one will dispute the energy that has been thrown into the business—till the name is as well known as that of any interested in the industry. There is no doubt but that electrical work is growing, and will continue to grow, and that firms or companies that determine to give good workmanship and refuse business at an unremunerative figure, except when it is intended to be scamped, will find plenty to do in the near future. Some further particulars will be found at the end of the paper.

THE ELECTRIC LIGHTING ACT.—Mr. Hugh Watt has now placed the following notice of motion on the order book of the House of Commons:—"That the experience gained since the passage of the Electric Lighting Act of 1882 having demonstrated the impracticable provisions of that Act, no measure short of its repeal and the substituting thereof of legislation rendering it possible to supply electric light to the public with a fair prospect of remunerative returns will be of any benefit to the electric lighting industry, and as that Act has to a very large extent destroyed the growth of the industry in this country, and driven the export trade into American hands, it is desirable that the aforesaid Act be forthwith repealed, and those engaged in this new industry (which now employs nearly £50,000,000 of capital and over 50,000 workmen in America) be freed from the fetters of legislation which have proved of so disastrous a character."

ATMOSPHERIC ELECTRICITY.—Some instructive experiments on atmospheric electricity are described by Herr Nahrwold in *Wiedemann's Annalen*, No. 7. He thinks it established that the action of electricity from points on finely divided matter in the air does not electrify the air itself statically (indeed, that air and other gases probably cannot be statically electrified), but only dust particles in it. A glowing platinum wire sends out particles which diffuse in air that has been electrically freed from dust, making a fresh charge possible. Here, too, the electricity streaming from such wire does not statically electrify the air; but the charges which are observed as atmospheric electricity belong to fine non-gaseous particles given out by the wire, or already present in the air. An experiment is also adduced to show that at ordinary temperature negative electricity of high potential streams from solid conductors into atmospheric air more readily than from positive.

THE ELECTRIFICATION OF GASES BY IGNITED BODIES.—From investigations by J. Elster and H. Geitel the following facts have recently been determined:—"(1) The phenomenon that insulated conductors near an ignited body are electrically charged holds also for gases which have been freed from dust by filtration through glycerine wadding. (2) This holds also even when the rarefaction is raised to the extreme limits of a Crookes tube. (3) The electrification is positive for red heat, and all temperatures beyond in all gases as yet examined, with the exception of hydrogen, which at a high temperature has the opposite behaviour. (4) For air and carbonic acid the maximum of electrification is at a yellow heat. (5) The layer of gas which surrounds an incandescent body shows a different deportment as respects positive and negative electricity. That electricity whose sign is opposite that developed in the gas by ignition is most rapidly discharged."

THE BRITISH ASSOCIATION.—At the Manchester Town Hall, on Wednesday last, a meeting of the local general committee was held to receive the report of the executive committee of the British Association with reference to the approaching meeting in Manchester. Mr. Alderman Goldschmidt, who presided, said that the evidence already to hand indicated that this meeting would be a very remarkable one. The attendance of foreign members would be unprecedented both as regarded numbers and rank, and he had the privilege of announcing, as additions to the published list of very distinguished personages, the name of the Emperor of Brazil, who had been a member of the association since 1871, and was one of the wisest and most learned monarchs who ever sat upon a throne, and also that of a representative of the Congo Free State, who had been expressly nominated by the King of the Belgians. The report of the executive committee was read and adopted.

A REED TELEPHONE.—With the idea of obtaining more perfect articulation in the receiver, Mr. A. G. Safford, of Washington, has devised a telephone in which a number of sector-shaped reeds, of different widths and thicknesses, are put together so as to complete a circular disc, having a small

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central aperture. The reeds are held by screws at their outer margins, and are free to vibrate independently. These reeds are timed to different rates of vibration, and each semi-tone of an entire octave of the diatonic scale is represented. Each reed has a magnet pole set underneath, and these poles project from a single core upon which the coil is wound. The idea is that every harmonic in the human voice shall find at least one portion of the diaphragm capable of responding to its rate of vibration. For the transmission of vocal or instrumental music with the least possible degradation, probably this instrument is better adapted than the ordinary form. Beyond this it seems impossible to say anything for the idea.

POROUS CELLS OF CORK.—The construction of porous cells appears to be receiving attention at the present time in several quarters. There is no doubt that in respect of weight and fragility clay cells present disadvantages which it is well worth while to seek to avoid. We mentioned last week the use of vulcanised fibre for this purpose; since then we learn that M. Stein, of Bonn, has succeeded in making porous cells of cork waste. The cork is first reduced to a finely pulverised form, and is then made up into a sort of stiff paste by the addition of naphthaline diluted with a certain quantity of water. Moulds of the required form are filled with the mixture, which is then dried at a gentle heat. A certain portion of the naphthaline is driven off and is recovered for further use. The cells thus made are extremely cheap, and weigh very little. They are also said to be both strong and durable, and to possess a suitable degree of porosity. In addition to these advantages, it is also said that the presence of the naphthaline prevents the formation of salts upon or within the walls of the cell.

THE LIGHTING OF THE VIENNA OPERA.—The electric lighting of the Vienna Opera House, which has been undertaken by the British and Continental Gas Association, was expected to have been completed by Sunday last, when the theatre was to have been re-opened. It was, however, found necessary to postpone the opening for a week, the work, which was only commenced six weeks ago, not being quite finished. The dynamos are of the Crompton vertical type with double horseshoe magnets, and give an output of 120 amperes at 600 volts. They are employed to charge in series five sets of batteries which discharge over independent circuits. The lighting of the stage is controlled by a special switch connected with both arc and incandescent lamps enclosed in globes of various colours, and the combinations are so arranged as to give the effects of daylight, dawn, sunset, the furious blaze of a conflagration, or pale silvery moonlight. It is anticipated that these effects will surpass anything of the kind hitherto attempted. To avoid any unnecessary disturbance of the walls, which are very handsomely decorated, it was found possible to make use, to a considerable extent, of the gaspipes as channels for the wiring.

TRANSFORMERS.—The question as to the best value to give to the periodic time of alternations of the current in a system of transformers is a somewhat complex one, inasmuch as the period cannot receive any adjustment without at the same time upsetting the conditions under which the dynamo is worked. It is, however, evident that a transformer having a wire core, can, other things being equal, be economically worked at a higher rate of alternation than one with a plate core. In practice there has been a tendency to reduce the number of alternations at first employed. The Gaulard-Gibbs transformers commenced with 150 alternations—a number which was probably arrived at merely because it happened to suit the available dynamos. Some later systems, in which plate cores are used, and for which special dynamos are supplied, run at 100 alternations. But, on the other hand, the Zipernowski-Déri system, which has a wire core, and which started at 80 alternations, has now, we understand, been reduced to the low figure of 50. It is obviously advantageous to keep the period as short as possible provided that the loss by Foucault currents in dynamos and transformers together does not exceed the economical limit.

LAMPS PER HORSE-POWER.—*Light, Heat, and Power* gives the following figures relating to the commercial efficiency of dynamos at different outputs. The first set of tests were made by our contemporary upon a 200-light machine built by a prominent company four years ago, and "using the most improved lamps now made by that company." In both this and the following test the lamps were kept up to 16 candle-power.

178	lights	required	24·4	H.-P.,	equals	7·3	lights	per H.-P.
91	,,	,,	14·36	,,	,,	6·34	,,	,,
45	,,	,,	9·08	,,	,,	4·96	,,	,,
5	,,	,,	4·79	,,	,,	1·04	,,	,,

Dynamos only, no lights, 3·07 H.-P.

The second set of tests were made upon a 400-light machine supplied by a younger company, and show a marked improvement in efficiency.

400	lights	required	40·89	H.-P.,	equals	9·98	lights	per H.-P.
300	,,	,,	30·82	,,	,,	9·70	,,	,,
200	,,	,,	20·91	,,	,,	9·5	,,	,,
100	,,	,,	12·28	,,	,,	8·1	,,	,,
50	,,	,,	7·75	,,	,,	6·4	,,	,,

Dynamos only, no lights, 3·78 H.-P.

NEWCASTLE-ON-TYNE.—At the Newcastle-on-Tyne Exhibition an incident occurred last week which is thus reported in a local journal:—"A singular accident occurred on Saturday with one of the electric lamps at the Newcastle Exhibition. One of the lamps had been lowered for the purpose of being tested, when a Miss M'George, an attendant at the Everton toffee stall, stepped forward and put her hand on the top of the lamp. Immediately she received a severe electric shock, and could not remove her hand. Another Exhibition attendant, hearing her screams, ran forward and took hold of the unfortunate young woman, but she, too, merely by taking hold of Miss M'George, received a shock which caused her to scream out. She, however, succeeded in dragging the former from her position. Both were taken to the Ambulance Hospital. Miss Woolland, the second victim by the mishap, quickly recovered, but Miss M'George seemed to have suffered severely by the shock, and was a considerable time in recovering sufficiently to leave the hospital." While we are sorry for Miss M'George's sufferings, it cannot be denied that an incident of this kind is not altogether without its value, if only in demonstrating that an electric shock is not necessarily fatal. But we should like to know what the man who lowered the lamp was doing to allow it to be meddled with in this way.

SEVERE THUNDERSTORM IN PARIS.—The following is the *Daily News* account of a severe storm in Paris on Sunday last:—"An extremely violent thunderstorm interrupted yesterday the drought in this part of the world. The weather for a few hours before it broke was suffocating in its sultriness, and the sky was so black that day was as night. Then suddenly, at two o'clock in the afternoon, a deluge of rain came pouring down, and sweeping along the streets, which in a few moments were as rivers. If all the artillery of the German Empire had been playing upon the city the noise could not, perhaps, have been greater than that caused by the fast-recurring peals of thunder. In the Avenue de Main the lightning split an elm, and stunned eight persons who were taking shelter in a shed near it.

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In many parts of Paris trees have thus been damaged. A lightning rod next door to the Bank of France was struck with such force that all the panes in the glazed roof of the central court in that building were broken. A panic reigned for some moments, as it was feared that the iron roof was coming down with the glass. The office of the *Figaro* was struck by the lightning, attracted by a metal chimney pot, from which it ran to a balcony railing, and thence into the machine room where the printers were at work. It destroyed some insignificant objects, and made its exit by the shaft of a lift into a cellar."

GLASGOW.—*Industries* gives the following account of the recent negotiations for the lighting of the City Hall, Bazaar, and Municipal Buildings at Glasgow:—Some time ago the Town Council advertised for tenders for an installation of electric light for these three buildings. Two of them are close together, and the third is at a distance of a few hundred yards. The original intention was to light all three from a central station, to be situated in or near the Bazaar or public market. Between twenty and thirty tenders were received, and these differed so widely, both as to methods and costs, that the committee in whose hands the matter rested sought the advice of Mr. W. A. Bryson, electrician at the Manchester Exhibition. Mr. Bryson reported that the City Hall should be lighted by 13 to 15 arc lamps in series, and that the Bazaar should be lighted by a similar number, the current for each circuit being obtained from a dynamo and small engine under or near the Bazaar. Mr. Bryson recommended also that the Municipal Buildings should be lighted mainly by arc lamps, and the smaller rooms and corridors alone fitted with incandescent lamps, the generating plant being placed at the Bazaar or some other building within a reasonable distance of the Municipal Buildings. The committee resolved to carry out the lighting of the Municipal Buildings independently of the City Hall and Bazaar, but ultimately decided to reconsider the whole subject. One of the buildings is now approaching a stage when it will be necessary to decide promptly whether it is to be lighted by gas or electricity.

ARC LIGHTING CONTRACTS IN THE UNITED STATES.—The following figures will serve to show the average cost of electric lighting in American towns. The candle-power contracted for per lamp is invariably 2,000, except in Brooklyn, where it is only 1,200:—

Town.	No. of lamps.	Price per night. Cents.	System.	Length of contract.
New York ..	711	70	Brush United States	1 year
Philadelphia ...	525	54	Brush United States Thomson-Houston	1 year
Brooklyn	995	50	Thomson-Houston	1 year
Boston	504	65	Brush, Weston Thomson-Houston	3 years
Newark	150	50	United States Weston	3 years
Providence, R.I.	175	50	Weston Thomson-Houston	1 year
Albany	481	50	Brush	5 years
Rochester, N.Y.	309	45	Brush	5 years
	77	30		

At Albany, Boston, and Philadelphia the lamps, posts, poles, and lanterns are in part, or altogether, the property of the towns. From a note in another column it will be seen that the high price now obtained in New York has attracted competition, and the Brush and United States Companies, which now share the field between them, are likely to find a powerful rival in the Thomson-Houston.

A REMARKABLE INSTALLATION AT BRUSSELS.—The electric lighting of the Théâtre de la Monnaie at Brussels has been placed in the hands of Gérard and Co., who, we are informed, intend to employ transformers, which will be supplied with current from a generating station situated at the gas works nearly three miles distant. The installation will consist of about 400 lamps, and the contract amounts to £4,950. The transformers to be employed are of a new type, designed by M. Gérard, and provision is also made for charging a set of batteries to be capable of lighting the theatre for five hours in the case of a breakdown. Some mystery is being maintained as to the means which are to be employed for charging these batteries. It would of course be possible by means of a small alternating current machine used as a motor to commutate the transformer current and charge the cells in this way, and several experiments have recently been made in this country in the direction indicated, but the difficulty of making the motor self-starting, of exciting its field, and of suppressing sparks at the commutator has hitherto hindered any satisfactory results. In the Brussels case, however, the two first-named difficulties would be less serious because the conditions probably admit of the provision of skilled attendance in charge of the batteries. The sparking difficulty can also, we believe, be overcome. There remains the economical objection of the double transformation, but if the efficiency of the Gérard transformers is as high as is usually claimed for this class of apparatus, this objection also is not very serious. It was intended at first to employ the Gadot accumulator, but at the last moment these were abandoned in favour of the Julien. Engines are provided for 75 horse-power. The dynamos are four in number. The work is to be completed under a heavy penalty by the 1st October, and the contractor guarantees to maintain the service in good order until the 1st January, 1889.

COUPLING ALTERNATING MACHINES.—It is well known that when two alternating current machines are coupled in parallel they tend automatically to acquire uniform phase. In practice, however, if it is required to add another machine in parallel with one already at work upon a lighting circuit it is inconvenient to await this automatic adjustment, for so long as the phases are not absolutely coincident, the mean difference of potential at the lamp terminals will obviously be less than the normal. In order to overcome this difficulty Messrs. Siemens and Halske have devised an arrangement in which the machine to be brought into circuit has its terminals connected with mercury contacts which are operated by an electromagnet switch. The magnet is wound with two equal coils, one of which is placed in circuit with the latter machine and the other as a shunt with the machine already in action. The armature is held back by an opposing spring until the attraction of the core is at a maximum, which is not until the two currents are uniform in phase. The armature then falls over, bridging the mercury contacts and putting the second machine upon the lamp circuit. If Messrs. Siemens have found this arrangement to work satisfactorily in practice, we have naturally no theoretical objection to raise against it. But, taking the description as it stands, it is clear that the device is open to question, on the ground that the phase of the current in the magnet coil which is placed as a shunt upon the terminals of the machine in action is not identical with the phase in the main circuit, unless the ratio of self-induction to resistance is the same in these two branches. No doubt this difficulty might be overcome by making the resistance and self-induction of the magnet coil as small as possible, and increasing the total resistance of the shunt by the use of non-inductive resistance, such as incandescent lamps. This would probably

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entail the employment of a second electro-magnetic switch, the first being used merely as a relay. The problem is a pretty one, and it obviously admits of more than one solution.

NON-POLAR DYNAMOS.—It is not our intention at the present moment to express any editorial opinion upon the merits of the controversy upon the so-called non-polar type of dynamo machine which has lately occupied our correspondence columns; but as some of our correspondents appear to be rather in want of experimental data upon which to base their theories, we print herewith the passage in De la Rive's "Electricity," to which Mr. Voice referred, somewhat inaccurately, in his first letter. De la Rive (Vol. I., page 435) says:—"Mr. Weber's experiment differs from those of Faraday in that the magnet, being arranged so as to rotate on its horizontal axis, carries a metal disc through which it passes tightly, and which can be slipped so as to be placed upon different sections of the magnet. This disc is plunged by its lower part in a cup full of mercury, into which is inserted one of the ends of the galvanometer wire, whilst the other communicates with the axis of the magnet itself. On making the magnet rotate upon its axis, a continuous current is obtained, the direction of which depends upon that of the rotation, and the intensity of which varies proportionately with the velocity of this rotation. But the intensity depends also essentially upon the power of the magnet, and especially upon the distribution assumed by the magnetism in it, for it greatly changes according as the magnet that serves for the operation is subjected or not at its two extremities to the action of the contrary poles of two powerful auxiliary magnets that are brought near to it. The length of the space on the surface of the magnet and parallel to its axis has no sensible influence over the force of the current. For this force is the same when the brass disc being fixed at one or other of the two extremities of the magnet, the end of the galvanometer not in communication with the disc is placed in contact with the north end and the south end—that is to say, with that which is nearest to or with that which is most distant from the disc. However, the absolute effect is less considerable in this case that it is when the brass disc is in the middle of the magnet."

PHELPS'S ELECTRO-MOTOR ROCK DRILL.—Now that the construction of electric motors has at length been placed upon a sound footing, both in this country and in America, the application of electricity to the working of machinery and machine tools may be expected to receive a rapid development. One of the most obvious applications of this nature is for driving rock drills. This was first attempted some years ago by Messrs. Siemens and Halske, but at that period the weight and efficiency of the then available motors was against the complete success of the method. More recently, as our readers are aware, Mr. C. E. Rowan has worked in the same direction, and has attained very promising results in drilling and riveting iron plates in the shipbuilding yards at Dumbarton. We now learn that Mr. Phelps (whose name is already known in connection with induction telegraphs applied to moving trains) has designed a rock drill applicable for mining and tunnelling operations. As regards economy machines of this class ought now to be able to beat compressed air entirely out of the market were it not for the fact that ventilation is provided at the same time by the air motors. When, however, we remember that the efficiency of the latter apparatus seldom exceeds 25 per cent., there is room to hope that the margin of economy in the use of electricity may permit the employment of separate ventilating appliances, in which also electricity may play a useful part. It is to us a matter of some surprise that so few electrical firms have as yet broken ground in this and many similar directions. In the Phelps rock drill the drill itself is driven by two short cranks attached to either side of the armature; but in order to give a thrusting rather than a hammer action, and at the same time to deaden the shock and jar upon the frame, two spiral springs are attached to the stock of the axle in such a manner that in an extreme position one spring is compressed and the other extended. The remaining mechanical details appear to have been well thought out, but the motor, which has been especially designed to meet the above conditions, will scarcely commend itself to the English eye. The armature is of the Gramme ring type, and is mounted between the poles of two horseshoe magnets. The four poles are not only unsymmetrical, but they are flat at the ends, and project considerably beyond the armature at either side.

MAKING MIRRORS FOR REFLECTING GALVANOMETERS.—Dr. James B. Williams, writing in the *Electrical World*, of New York, gives the following directions to amateurs who wish to make their own mirrors for reflecting galvanometers:—"The making of these little mirrors is a tedious operation to many, but a method practised by myself, and which has given very good results, is the following: Take five or six thin glass circles, such as are used in mounting microscopic objects, and clean them thoroughly by rubbing them with a small piece of cotton tied to a stick, which has been dipped in nitric acid. Then wash them in a solution of caustic potash, or strong ammonia water, and finally rinse them first in clean and then in distilled water. Dry them thoroughly with a piece of soft linen rag, and fasten them on a piece of cardboard with mucilage, by placing small drops of mucilage near the edge of a card and allowing the circles to fall upon them. Next, take a piece of good looking glass and cut out circles of the alloy upon the back of it near the edge, by laying a coin a little larger than the glass circles upon the alloy, and draw a sharp pointed instrument around the edge of the coin. Remove all of the alloy between the circles and the edge of the looking glass so that the circles of alloy can be slid over the surface of the looking glass and on to the thin glass circles gummed on the card. The circles of alloy are loosened from the looking glass by placing a globule of mercury upon them and spreading it over them with the finger; after which they can be gently pushed on to the glass circles, the edge of the card being held against the edge of the looking glass. After placing the circles of alloy upon the thin glasses, press them gently with the fingers upon all portions. Next cut discs from a piece of heavy tinfoil, a little larger than the circles of alloy, lay them gently upon the latter, and press them firmly upon the alloy. By so doing all of the superfluous mercury is removed from the alloy and unites with the tinfoil. The outer alloy, formed by the union of the mercury and tinfoil, is then removed by scraping it gently with the edge of a sharp knife blade. A coating of shellac dissolved in alcohol is then painted over the backs of the mirrors, and after it has become dry the mirrors are removed from the card by moistening the latter with water. I have used mirrors made according to the above-described process in my galvanometers and electrometer, and find they will, when used with a biconvex lens, give an excellent definition of a cross hair three and four feet away from the mirror. The beginner had better practice upon thick glass circles, for he will be most certain to break thin ones while pressing the alloy upon the glasses. The mirrors will be found to answer all purposes except in the cases where an extremely light mirror (as in a Thomson astatic galvanometer of high resistance) is required, when the silvering process should be used. If the process be successfully performed, the mirrors can be broken before the alloy will leave the glass."

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COMPARISON BETWEEN THE VIEWS OF DR. ARRHENIUS AND PROF. ARMSTRONG ON ELECTROLYSIS.

BY OLIVER LODGE, F.R.S.

A Communication to be made to the British Association Committee on Electrolysis.

It may be convenient to summarise the main views of Prof. Armstrong concerning electrolytic conduction, as expressed in his Royal Society Memoir (*Proc.* Royal Society, No. 243, 1886). He discards the view of exact equivalence between the positive and negative atoms of a compound, considering that no ordinary molecule is really saturated, but that its electro-negative element has an unsatisfied or residual affinity, with which it is ready to cling on to fresh atoms or to other like molecules. By means of these residual affinities of unsatisfied atoms he imagines molecular aggregates to be built up. And he considers a concentrated substance in the liquid state to be largely or wholly composed of these complex molecular aggregates, each in a nearly or quite saturated, and therefore inert, condition. The effect of dilution, however, is to break up these aggregates into simpler molecules, until, in an extremely dilute solution, the molecules may be as separated and as simple as they are in the gaseous state.

So far the views of Arrhenius* somewhat correspond. Without any doctrine of residual affinity as accounting for them Arrhenius also postulates the existence of molecular aggregates, which he imagines to be broken up by dilution; but he goes further, and imagines a certain number of the molecules themselves broken up by dilution into their constituent atoms, *i.e.*, he postulates real dissociation after the manner of Williamson and Clausius, a hypothesis for which Prof. Armstrong sees no necessity, and to which he apparently perceives some chemical objection.

The dissociated molecules are called by Arrhenius the "active part" of the liquid, and are believed to be the only ones which take part directly either in chemical action or in electrolytic condition. These are the molecules which are constantly exchanging their atoms, either with each other or with foreign molecules, and so giving rise to double-decomposition and ordinary chemical action. All other molecules, having their atoms firmly combined, are inert. Heating and dilution increases the active portion, *i.e.*, the proportion of dissociated molecules, and thus intensifies at the same time the chemical power and the electrolytic conductivity of the compound. To every state of temperature or admixture, a certain proportion exists between the active and inactive molecules of a given substance; and thus its "activity" or "avidity" in chemical reaction, as well as the current it can convey under the influence of a given E.M.F., *i.e.*, its conductivity, is regulated and determined. The velocity of chemical action between the mixed substances, *i.e.* the rate at which their molecules interchange atoms, can thus be calculated in arbitrary time-units from a knowledge of the conductivity of the constituent substances; and the final state of equilibrium is obtained by putting this rate equal to zero.

The special point of Arrhenius's paper is therefore not any peculiar view which he holds regarding the nature of electrolysis, for his view is a perfectly orthodox one, but it is the application which he makes of it in the consideration of all manner of chemical reactions; he attempts, in fact, an Electrolytic Theory of Chemistry.

Prof. Armstrong, on the other hand, holds, provisionally at any rate, quite heterodox views as to the nature of electrolysis, which, so far as I understand them, appear to be these:—

So soon as an E.M.F. is applied to a liquid a locomotion of the *molecules* past each other begins, as evidenced by the known occurrence of electric endosmose. By this process every salt molecule is brought within range of a water molecule as they slide past each other, and the residual affinity of some constituent of each of two molecules straining at each other under these conditions, superadded to the strain already set up by the applied E.M.F., is sufficient to effect disruption of the molecule, whose separated atoms then travel opposite ways to the electrodes, carrying their charges with them, and conduction occurs in the manner ordinarily assumed. For instance, in a solution of HCl in H_2O, the O is straining at the Cl, and this force, as they flow past each other, is sufficient to assist the applied E.M.F. to produce disruption and interchange, *i.e.*, to bring about the same result on the Williamson-Clausius dissociated condition ordinarily supposed to exist *before* the action of E.M.F.

If, however, the molecules in the liquid are all complex molecules, or aggregate of a large number of atoms, hanging together by the residual affinity of each, these residual affinities are in the complex so nearly satisfied that they have no further power to act on a water or other molecule; and they thus resist being broken up, and refuse to conduct a current. A liquid composed wholly of such complex aggregates is thus not an electrolyte; and Armstrong calls it a pseudo-dielectric.

A liquid which contains among a large proportion of such aggregates a few simple molecules here and there is an electrolyte but a very badly conducting one. Its conductivity increases as the aggregates get broken down, whether by heat or by dilution.

It will be observed that this hypothesis does not dispense with dissociation; it only denies dissociation previous to the application of E.M.F. So soon as E.M.F. is applied, mutual action between the molecules, assisting the strain caused by the E.M.F. itself, produces the very state of dissociation postulated by all physicists as necessary for actual electrolytic conduction.

Neither does the hypothesis dispense with a dissociating power of the solvent; it only limits its power to the breaking down of complex molecules, instead of allowing it to break up the simple molecules themselves. It is not supposed able to do this latter until aided by applied E.M.F.

To summarise.—The orthodox view supposes fully combined molecules, whether aggregates or not, to be undecomposable by any moderate E.M.F.; but it supposes a certain proportion of them split up or dissociated, either actually or potentially, by addition of a foreign body. Not necessarily a *solvent*: it pictures the dissociation of water by salt quite as easily as that of salt by water. Each atom while in the nascent or uncombined state has associated with it a definite electric charge, and these loose electrified atoms are thus immediately amenable to the smallest directive E.M.F.

Armstrong's view supposes complex molecules to be undecomposable by any moderate E.M.F., but it imagines a certain proportion of them split up or decomposed into simpler molecules by the action of a solvent. It supposes, further, a tendency or endeavour on the part of the water to split up these simple molecules still more into their constituent atoms; but it asserts that the water is unable to effect this until aided both by an extra strain, in the shape of an externally applied E.M.F., and by the locomotive disturbance or endosmose thereby set up in the liquid.

A third view there is, which must probably have been held more or less distinctly by several physicists, and which for several reasons usually commends itself to me, viz., that all *simple* molecules are strongly combined, and therefore intractable to feeble E.M.F.'s; and that most perfectly pure bodies, undisturbed by heat or by admixture with foreign matter, have their molecules in this condition. When, however, two or more substances (like salt and water for instance) are mixed together, their simple molecules combine into somewhat indefinite molecular aggregates or hydrates of complex structure, in which it may happen either that some of the outlying atoms are not held with full vigour, and so become partially free and able to interchange with other similarly placed atoms, or else that by the collision of the unwieldy aggregates with each other the atoms of one molecule are brought so close to the respectively opposite atoms of another molecule that a mutual interchange occurs.

For it is well known that it is quite unnecessary to postulate atoms as hovering around in an entirely free or disemmoleculed condition. All that is wanted to explain the facts of electrolysis

* "Recherches sur la Conductibilité galvanique des Electrolytes (152 pages), par Svanté Arrhenius. Mém. presenté à l'Acad. des Sciences de Suède le 6 Juin, 1883. Abstract and semi-translation appear in recent B.A. Report.

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is a certain number of atomic interchanges occurring at random; for the slightest E.M.F. will then suffice to exert a directive influence one way or the other on the atoms during their infinitesimal moment of freedom.

The operation is perhaps more simple to contemplate if the atoms are imagined to be actually, instead of only, so to speak, potentially free; but the result is the same, and, of course, the conductivity will depend upon the number of such "free" atoms existing in the solution, the *molecular* conductivity km representing the proportion of such free atoms to the whole. It is upon this very same proportion, according to Arrhenius, that the chemical activity of the substance depends.

Whatever be the most satisfactory form of hypothesis to hold at present, I am bound to say that the hypothesis of Dr. Armstrong does not commend itself to me. And that for several reasons.

I make no objection to his notion of residual affinity, nor to the formation of molecular aggregates by means of it. These are points for the consideration of chemists. The objectionable, and I venture to think fatal, part of his hypothesis, is where he supposes dissociation to be produced by means of the applied E.M.F., instead of independently of it. Few things are more certain than this, that an electrolyte is incompetent to resist the smallest E.M.F. really applied to it (*i.e.*, not applied only to electrodes.) If the molecules have to be torn asunder by any action depending on the magnitude of the applied E.M.F., it must be possible to choose an E.M.F. too weak to effect decomposition. A substance which needs an E.M.F. to tear its molecules asunder in the interior of its mass is *ipso facto* a dielectric—it may be a very weak one—but it is not an electrolyte. All that a slope of potential can possibly achieve in the interior of an electrolyte is to direct the procession of otherwise randomly moving atoms. This is of course the foundation of the theory of Williamson and Clausius; and all experimental knowledge acquired since the time it was first promulgated with regard to the obedience of electrolytes to Ohm's law, down to the researches of Prof. Fitzgerald and Mr. Trouton, communicated in part to the last British Association and still going on, tends but to confirm and strengthen that position.

Of course, at surfaces of discontinuity, *i.e.*, at electrodes, electrolytes need a finite E.M.F. to liberate their ions, but the range over which the stress here concerned acts is of atomic dimensions, say 10^{-8} centimetre from each electrode. There is no such finite stress needed, or possible, in the interior of a homogeneous liquid.

A minor objection to Dr. Armstrong's hypothesis may be made at the point where he supposes *endosmose* to precede conduction, and to be a phenomenon independent of surface contact. It is not easy, again, to imagine why his molecules should be travelling past *each other* in the fluid, nor why, even if they did, this fact should assist their previously incompetent forces to disrupt each other.

Unless every molecule is supposed to be in a condition extremely like every other molecule, which is quite contrary to the usual doctrine of averages as applied to molecules, it is difficult to believe that a number of molecules are in such a state of strain as to be made to break up with mere gentle locomotion, and yet that none of them shall be able to break up without such assistance.

I trust that in thus criticising Prof. Armstrong's views it will be perceived that I am actuated by none but friendly motives, and that I fully recognise the importance of the effort he is making to think out chemical phenomena in a physical way, and generally to associate Chemists and Physicists more closely together.

University College, Liverpool.

INCANDESCENT LAMP MANUFACTURE.—XXI.

BY J. SWINBURNE.

Testing (continued).

Before discussing the photometry of incandescent lamps it will be necessary to explain what is meant by such terms as "efficiency," "light of so many candles," &c., as these terms are generally used somewhat loosely.

If the electromotive force of a lamp is gradually increased from 0 till the lamp breaks, the light of the lamp increases, and so does the electrical power absorbed by the lamp. The light increases more quickly than the power, so that the ratio of the light to the power used increases.

If a body is at a white heat, so as to emit light, it emits light in all directions. The total light emitted is generally called the spherical intensity, but will here be called the total emission. When the light from a square centimetre of melting platinum is taken as the unit of white light the total emission is not referred to, and only the light emitted in a direction at right angles to the surface of the melting platinum is taken into account. If the surface of the melting platinum were turned through an angle so that the line from it to the observer was no longer normal to the surface, the light emitted in this direction would decrease. If the observer is so far off that a centimetre is very small in comparison with the distance, the light observed is equal to the light observed when the plane of the surface was at right angles, multiplied by the cosine of the angle the surface is turned through. Thus when the platinum is turned through 90 deg., it is edge on towards him and emits no light in his direction. The light emitted in his direction thus varies as the projection of the surface on a plane at right angles to the line from the observer. The light emitted in the direction of the observer thus varies as the apparent area of the source of light, or as the area of paper it would occupy if the observer made a perspective drawing of it as he saw it.

Any illuminating surface may be looked upon as made up of an infinite number of infinitesimally small planes. Suppose a line drawn from the centre of one of these planes, dS, to the observer; the light emitted would be proportional to the intensity of the source—that is, to the amount of light which would be emitted by a plane square centimetre of the surface in a direction at right angles to it; call this I; to the area dS, and the cosine of the angle, which we may call ϵ, which the normal to the plane makes with the line from the little plane to the observer. The amount of light which enters the eye of the observer varies inversely as the square of the distance r from the plane, so that the light observed from the little plane is $\frac{1}{r^2}$ I cos ϵ dS, and the whole light which enters the eye of the observer is $\iint \frac{1}{r^2}$ I cos ϵ dS, an expression which will be familiar to electrical readers. This means that the light received at any point from a source of any shape whose surface is uniformly luminous varies as the solid angle subtended by the surface at the point. Thus to find the intensity of illumination at a point on the disc of the photometer due to any source of light, such as, for instance, a lump of white hot carbon, imagine a sphere of one centimetre radius described round the point, and imagine a wire with one end fastened at the point on the disc, stretched past the lump of carbon, and held so as to touch the carbon. If the wire was moved so as to go round the lump of carbon just touching it and still stretched, it would trace out an irregular pyramid, with the apex at the point on the disc; this would be the solid angle. The wire would also trace out an irregular surface on the sphere, which would be the shape of the carbon lump as seen by a tiny observer at the point on the screen. The area of this surface would be a measure of the solid angle, and if multiplied by the intensity of unit surface of the lump would be a measure of the intensity of the illumination at the point on the disc. This explains why such a thing as a white hot lamp carbon looks equally bright all over, so that it is impossible to see with one eye whether it is round or flat. It also shows why a rough surface and a smooth give out the same light in any direction if the outlines are the same; thus, if two carbons are the same size and are run at the same temperature they give the same light, even if one is rough and the other smooth.

Instead of talking about the light received by the observer's eye the term illumination may be used, the illumination at any point is then the light received per square centimetre of surface.

The next point to consider is the relation between the light

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COMPARISON BETWEEN THE VIEWS OF DR. ARRHENIUS AND PROF. ARMSTRONG ON ELECTROLYSIS.

BY OLIVER LODGE, F.R.S.

A Communication to be made to the British Association Committee on Electrolysis.

It may be convenient to summarise the main views of Prof. Armstrong concerning electrolytic conduction, as expressed in his Royal Society Memoir (*Proc.* Royal Society, No. 243, 1886). He discards the view of exact equivalence between the positive and negative atoms of a compound, considering that no ordinary molecule is really saturated, but that its electro-negative element has an unsatisfied or residual affinity, with which it is ready to cling on to fresh atoms or to other like molecules. By means of these residual affinities of unsatisfied atoms he imagines molecular aggregates to be built up. And he considers a concentrated substance in the liquid state to be largely or wholly composed of these complex molecular aggregates, each in a nearly or quite saturated, and therefore inert, condition. The effect of dilution, however, is to break up these aggregates into simpler molecules, until, in an extremely dilute solution, the molecules may be as separated and as simple as they are in the gaseous state.

So far the views of Arrhenius* somewhat correspond. Without any doctrine of residual affinity as accounting for them Arrhenius also postulates the existence of molecular aggregates, which he imagines to be broken up by dilution; but he goes further, and imagines a certain number of the molecules themselves broken up by dilution into their constituent atoms, *i.e.*, he postulates real dissociation after the manner of Williamson and Clausius, a hypothesis for which Prof. Armstrong sees no necessity, and to which he apparently perceives some chemical objection.

The dissociated molecules are called by Arrhenius the "active part" of the liquid, and are believed to be the only ones which take part directly either in chemical action or in electrolytic condition. These are the molecules which are constantly exchanging their atoms, either with each other or with foreign molecules, and so giving rise to double-decomposition and ordinary chemical action. All other molecules, having their atoms firmly combined, are inert. Heating and dilution increases the active portion, *i.e.*, the proportion of dissociated molecules, and thus intensifies at the same time the chemical power and the electrolytic conductivity of the compound. To every state of temperature or admixture, a certain proportion exists between the active and inactive molecules of a given substance; and thus its "activity" or "avidlty" in chemical reaction, as well as the current it can convey under the influence of a given E.M.F., *i.e.*, its conductivity, is regulated and determined. The velocity of chemical action between the mixed substances, *i.e.* the rate at which their molecules interchange atoms, can thus be calculated in arbitrary time-units from a knowledge of the conductivity of the constituent substances; and the final state of equilibrium is obtained by putting this rate equal to zero.

The special point of Arrhenius's paper is therefore not any peculiar view which he holds regarding the nature of electrolysis, for his view is a perfectly orthodox one, but it is the application which he makes of it in the consideration of all manner of chemical reactions; he attempts, in fact, an Electrolytic Theory of Chemistry.

Prof. Armstrong, on the other hand, holds, provisionally at any rate, quite heterodox views as to the nature of electrolysis, which, so far as I understand them, appear to be these:—

So soon as an E.M.F. is applied to a liquid a locomotion of the *molecules* past each other begins, as evidenced by the known occurrence of electric endosmose. By this process every salt molecule is brought within range of a water molecule as they slide past each other, and the residual affinity of some constituent of each of two molecules straining at each other under these conditions, superadded to the strain already set up by the applied E.M.F., is sufficient to effect disruption of the molecule, whose separated atoms then travel opposite ways to the electrodes, carrying their charges with them, and conduction occurs in the manner ordinarily assumed. For instance, in a solution of HCl in H_2O, the O is straining at the Cl, and this force, as they flow past each other, is sufficient to assist the applied E.M.F. to produce disruption and interchange, *i.e.*, to bring about the same result on the Williamson-Clausius dissociated condition ordinarily supposed to exist *before* the action of E.M.F.

If, however, the molecules in the liquid are all complex molecules, or aggregate of a large number of atoms, hanging together by the residual affinity of each, these residual affinities are in the complex so nearly satisfied that they have no further power to act on a water or other molecule; and they thus resist being broken up, and refuse to conduct a current. A liquid composed wholly of such complex aggregates is thus not an electrolyte; and Armstrong calls it a pseudo-dielectric.

A liquid which contains among a large proportion of such aggregates a few simple molecules here and there is an electrolyte but a very badly conducting one. Its conductivity increases as the aggregates get broken down, whether by heat or by dilution.

It will be observed that this hypothesis does not dispense with dissociation; it only denies dissociation previous to the application of E.M.F. So soon as E.M.F. is applied, mutual action between the molecules, assisting the strain caused by the E.M.F. itself, produces the very state of dissociation postulated by all physicists as necessary for actual electrolytic conduction.

Neither does the hypothesis dispense with a dissociating power of the solvent; it only limits its power to the breaking down of complex molecules, instead of allowing it to break up the simple molecules themselves. It is not supposed able to do this latter until aided by applied E.M.F.

To summarise.—The orthodox view supposes fully combined molecules, whether aggregates or not, to be undecomposable by any moderate E M.F.; but it supposes a certain proportion of them split up or dissociated, either actually or potentially, by addition of a foreign body. Not necessarily a *solvent:* it pictures the dissociation of water by salt quite as easily as that of salt by water. Each atom while in the nascent or uncombined state has associated with it a definite electric charge, and these loose electrified atoms are thus immediately amenable to the smallest directive E.M.F.

Armstrong's view supposes complex molecules to be undecomposable by any moderate E.M.F., but it imagines a certain proportion of them split up or decomposed into simpler molecules by the action of a solvent. It supposes, further, a tendency or endeavour on the part of the water to split up these simple molecules still more into their constituent atoms; but it asserts that the water is unable to effect this until aided both by an extra strain, in the shape of an externally applied E.M.F., and by the locomotive disturbance or endosmose thereby set up in the liquid.

A third view there is, which must probably have been held more or less distinctly by several physicists, and which for several reasons usually commends itself to me, viz., that all *simple* molecules are strongly combined, and therefore intractable to feeble E.M.F.'s; and that most perfectly pure bodies, undisturbed by heat or by admixture with foreign matter, have their molecules in this condition. When, however, two or more substances (like salt and water for instance) are mixed together, their simple molecules combine into somewhat indefinite molecular aggregates or hydrates of complex structure, in which it may happen either that some of the outlying atoms are not held with full vigour, and so become partially free and able to interchange with other similarly placed atoms, or else that by the collision of the unwieldy aggregates with each other the atoms of one molecule are brought so close to the respectively opposite atoms of another molecule that a mutual interchange occurs.

For it is well known that it is quite unnecessary to postulate atoms as hovering around in an entirely free or disemmoleculed condition. All that is wanted to explain the facts of electrolysis

* "Recherches sur la Conductibilité galvanique des Electrolytes (152 pages), par Svanté Arrhenius. Mém. presenté à l'Acad. des Sciences de Suède le 6 Juin, 1883. Abstract and semi-translation appear in recent B.A. Report.

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is a certain number of atomic interchanges occurring at random; for the slightest E.M.F. will then suffice to exert a directive influence one way or the other on the atoms during their infinitesimal moment of freedom.

The operation is perhaps more simple to contemplate if the atoms are imagined to be actually, instead of only, so to speak, potentially free; but the result is the same, and, of course, the conductivity will depend upon the number of such "free" atoms existing in the solution, the *molecular* conductivity km representing the proportion of such free atoms to the whole. It is upon this very same proportion, according to Arrhenius, that the chemical activity of the substance depends.

Whatever be the most satisfactory form of hypothesis to hold at present, I am bound to say that the hypothesis of Dr. Armstrong does not commend itself to me. And that for several reasons.

I make no objection to his notion of residual affinity, nor to the formation of molecular aggregates by means of it. These are points for the consideration of chemists. The objectionable, and I venture to think fatal, part of his hypothesis, is where he supposes dissociation to be produced by means of the applied E.M.F., instead of independently of it. Few things are more certain than this, that an electrolyte is incompetent to resist the smallest E.M.F. really applied to it (*i.e.*, not applied only to electrodes.) If the molecules have to be torn asunder by any action depending on the magnitude of the applied E.M.F., it must be possible to choose an E.M.F. too weak to effect decomposition. A substance which needs an E.M.F. to tear its molecules asunder in the interior of its mass is *ipso facto* a dielectric—it may be a very weak one—but it is not an electrolyte. All that a slope of potential can possibly achieve in the interior of an electrolyte is to direct the procession of otherwise randomly moving atoms. This is of course the foundation of the theory of Williamson and Clausius; and all experimental knowledge acquired since the time it was first promulgated with regard to the obedience of electrolytes to Ohm's law, down to the researches of Prof. Fitzgerald and Mr. Trouton, communicated in part to the last British Association and still going on, tends but to confirm and strengthen that position.

Of course, at surfaces of discontinuity, *i.e.*, at electrodes, electrolytes need a finite E.M.F. to liberate their ions, but the range over which the stress here concerned acts is of atomic dimensions, say 10^{-8} centimetre from each electrode. There is no such finite stress needed, or possible, in the interior of a homogeneous liquid.

A minor objection to Dr. Armstrong's hypothesis may be made at the point where he supposes *endosmose* to precede conduction, and to be a phenomenon independent of surface contact. It is not easy, again, to imagine why his molecules should be travelling past *each other* in the fluid, nor why, even if they did, this fact should assist their previously incompetent forces to disrupt each other.

Unless every molecule is supposed to be in a condition extremely like every other molecule, which is quite contrary to the usual doctrine of averages as applied to molecules, it is difficult to believe that a number of molecules are in such a state of strain as to be made to break up with mere gentle locomotion, and yet that none of them shall be able to break up without such assistance.

I trust that in thus criticising Prof. Armstrong's views it will be perceived that I am actuated by none but friendly motives, and that I fully recognise the importance of the effort he is making to think out chemical phenomena in a physical way, and generally to associate Chemists and Physicists more closely together.

University College, Liverpool.

INCANDESCENT LAMP MANUFACTURE.—XXI.

BY J. SWINBURNE.

Testing (continued).

Before discussing the photometry of incandescent lamps it will be necessary to explain what is meant by such terms as "efficiency," "light of so many candles," &c., as these terms are generally used somewhat loosely.

If the electromotive force of a lamp is gradually increased from 0 till the lamp breaks, the light of the lamp increases, and so does the electrical power absorbed by the lamp. The light increases more quickly than the power, so that the ratio of the light to the power used increases.

If a body is at a white heat, so as to emit light, it emits light in all directions. The total light emitted is generally called the spherical intensity, but will here be called the total emission. When the light from a square centimetre of melting platinum is taken as the unit of white light the total emission is not referred to, and only the light emitted in a direction at right angles to the surface of the melting platinum is taken into account. If the surface of the melting platinum were turned through an angle so that the line from it to the observer was no longer normal to the surface, the light emitted in this direction would decrease. If the observer is so far off that a centimetre is very small in comparison with the distance, the light observed is equal to the light observed when the plane of the surface was at right angles, multiplied by the cosine of the angle the surface is turned through. Thus when the platinum is turned through 90 deg., it is edge on towards him and emits no light in his direction. The light emitted in his direction thus varies as the projection of the surface on a plane at right angles to the line from the observer. The light emitted in the direction of the observer thus varies as the apparent area of the source of light, or as the area of paper it would occupy if the observer made a perspective drawing of it as he saw it.

Any illuminating surface may be looked upon as made up of an infinite number of infinitesimally small planes. Suppose a line drawn from the centre of one of these planes, dS, to the observer; the light emitted would be proportional to the intensity of the source—that is, to the amount of light which would be emitted by a plane square centimetre of the surface in a direction at right angles to it; call this I; to the area dS, and the cosine of the angle, which we may call ϵ, which the normal to the plane makes with the line from the little plane to the observer. The amount of light which enters the eye of the observer varies inversely as the square of the distance r from the plane, so that the light observed from the little plane is $\frac{1}{r^2} I \cos \epsilon \, dS$, and the whole light which enters the eye of the observer is $\iint \frac{1}{r^2} I \cos \epsilon \, dS$, an expression which will be familiar to electrical readers. This means that the light received at any point from a source of any shape whose surface is uniformly luminous varies as the solid angle subtended by the surface at the point. Thus to find the intensity of illumination at a point on the disc of the photometer due to any source of light, such as, for instance, a lump of white hot carbon, imagine a sphere of one centimetre radius described round the point, and imagine a wire with one end fastened at the point on the disc, stretched past the lump of carbon, and held so as to touch the carbon. If the wire was moved so as to go round the lump of carbon just touching it and still stretched, it would trace out an irregular pyramid, with the apex at the point on the disc; this would be the solid angle. The wire would also trace out an irregular surface on the sphere, which would be the shape of the carbon lump as seen by a tiny observer at the point on the screen. The area of this surface would be a measure of the solid angle, and if multiplied by the intensity of unit surface of the lump would be a measure of the intensity of the illumination at the point on the disc. This explains why such a thing as a white hot lamp carbon looks equally bright all over, so that it is impossible to see with one eye whether it is round or flat. It also shows why a rough surface and a smooth give out the same light in any direction if the outlines are the same; thus, if two carbons are the same size and are run at the same temperature they give the same light, even if one is rough and the other smooth.

Instead of talking about the light received by the observer's eye the term illumination may be used, the illumination at any point is then the light received per square centimetre of surface.

The next point to consider is the relation between the light

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and the temperature of the carbon. Early in the century Draper made some rough experiments by which he showed that at the same temperature all bodies give out light of the same colour. This subject has since been followed up by many others, notably by Provostaye, Desains, and Kirchhoff. This law is very important in connection with incandescent lamps, for it shows that it is impossible to find a carbon which will at any temperature give out a larger proportion of the energy supplied it as light than another carbon does at the same temperature. That is to say, given the same vacuum, efficiency is a matter of temperature only, and one kind of carbon cannot give a higher efficiency than another without being run at a higher temperature. The only way, therefore, to get a carbon to give more light per watt is to make it so that it will stand a higher temperature without breaking.

Different bodies have different emissivities—that is to say, a piece of one with a total surface of one centimetre will at a given temperature give off more light than another piece of the same size at the same temperature. It will also give off more heat. If the temperatures are kept the same the first will need more power to keep the temperature up; but the light will be of the same colour in both cases, differing in quantity only. The efficiency will be the same, as the light will be of the same colour—that is to say, the same proportions of light and heat of different vibration frequencies will be emitted, so that the candles per watt will be the same.

These points have been dwelt on at some length because there are a great many popular errors on these subjects. Every now and then a maker brings out a carbon which he supposes has a higher efficiency than other makers' carbons. Efficiency is merely a matter of the temperature of the carbon if the vacuum is the same in each case, so that it is nonsense to say that lamps of one maker have a higher efficiency than those of another. All properly exhausted lamps have the same efficiency when seen at the same temperature—that is to say, at the same colour. One maker's lamp may stand being run brighter than another maker's without breaking, and is then a better lamp; but it cannot give a higher efficiency without being run brighter. If a lamp has a bad vacuum, of course heat will be conducted away by convection, and it will then take more power to keep the carbon at a given temperature, and so the efficiency will be comparatively low if the lamp is run at the same temperature as another lamp, and if the power is increased so that the lamp runs at the same efficiency it will have to be run at a higher temperature to make up for the loss by convection. There seems to be no difference of loss of heat by convection in most lamps by well-known English makers; but in America they do not seem to have studied exhausting so thoroughly, and so they may make what might be called low efficiency lamps.

The writer has tried experiments to see if carbons flashed at a high temperature so as to have a bright grey surface had more or less emissivity than when black. As it was difficult to measure the sizes of the carbons, a lamp was first made without flashing the carbon, and the power absorbed at ·3 candle-power watt was measured. The lamp was then opened and the carbon was flashed in highly rarefied coal gas, so that it became bright grey without getting perceptibly thicker. It was then pumped and tested again at the same efficiency, but took the same power, which shows that the emissivity was sensibly the same. If the emissivity were less it would of course have taken less power, being, say, a 15 candle-power instead of a 16 candle-power lamp, and if the same power as at first had been supplied it would have given more than 16 candle-power and would have run at a higher efficiency, but would have been at a higher temperature and would have given a whiter light.

As the melting platinum standard is not likely to come into immediate use, the light of lamps is always measured in standard candles. No one thinks of using standard candles for testing work. Generally some other standard, which has been compared with some such standard as the Gas Referees, is used. As by the "light" of a standard candle the total emission from the candle is not intended, so in the case of incandescent lamps the horizontal emission only is supposed to be measured. This would give no trouble if the horizontal emission were always the same proportion of the total emission of a lamp; but it is not, as the proportion evidently depends on the shape of the carbon. If two carbons of the same diameter and length, and therefore of the same surface, were made into lamps, the carbon in one lamp being as in the Swan lamp, and in the other in the form of a double corkscrew, as in the Wright and Mackie lamp, and if they were run at the same temperature, the carbon in the Swan lamp would obviously give more light horizontally than the other.

It becomes necessary, therefore, to define the term "candle-power" so that it depends on the size and temperature of the carbon and on nothing else, unless, indeed, it is necessary to include the emissivity, as the writer's experiments are scarcely conclusive on that point. The efficiency in candles per watt is, then, a measure of the temperature. This is of vital importance, as lamps should be run as bright as it is possible to run them without breaking them. One way would be to suppose a carbon measured as a sphere of the same surface, so that it would give out the same light in all directions; but this would be objectionable, because a lamp of the same nominal power as a gas jet would really give more light, so that the public, who would not understand that an electric lamp gave more light all round than a gas jet of the same nominal candle-power, would think gas cheaper. The writer always defines the candle-power as the light a carbon would give horizontally if it were in the form of a cylinder of the same surface held vertically. This seems much the simplest way, as in many cases it admits of direct measurement. Thus a carbon of circular section, bent into the form of a single loop, is simply held flatways towards the photometer.

If the carbon is bent into two or three loops it may be treated in the same way, as such carbons are thin, and the area covered by one part crossing in front of another is too small to make any perceptible difference. There is, of course, a small error due to the turns of the spiral not being in the same plane, so that their projection in the direction of the screen is slightly lessened—that is to say, an eye at the photometer would see these parts of the carbon what an artist would call foreshortened.

RECENT IMPROVEMENTS IN THE CARDEW VOLTMETER, PATERSON AND COOPER TYPE.

The annexed engraving shows an interior view of the latest form of the Cardew voltmeter, as constructed by Messrs. Paterson and Cooper. This instrument, as is well known, indicates difference of potential by the expansion of a fine wire heated by the passage of the current. Although this principle is sufficiently simple in theory, yet the construction of a practicable instrument required from the inventor a considerable amount of mechanical skill and ingenuity. Messrs. Paterson and Cooper have directed their endeavours towards simplifying the constructive details as much as possible. To this end they have, in the first place, done away with the supporting rods of the iron and brass by which the fine platinum-silver wires were upheld, and which were enclosed in the external brass tube. Instead of this arrangement compensation for temperature variation is secured by making the protecting tube itself in two parts properly proportioned, the lower of brass and the upper of iron. This modification enables high reading instruments to be made with four lengths of wire all in one tube, whereas previously two parallel tubes were employed to get room for the supporting rods.

The case containing the gearing of the instrument before us measures 6in. diameter by 2in. deep, the tube is 3ft. in length by 1½in. diameter, and the dial is calibrated up to 360 volts. The path of the current through the instrument is as follows:—

From the left-hand terminal T_1 a helix of silk-covered wire leads to a fuse piece, *f*, of 0·0015 platinum wire, mounted upon a block of vulcanised fibre. From thence the circuit is continued through the lower projecting arm to the German silver spiral *a*, which is about 1in. in length, and from this a length

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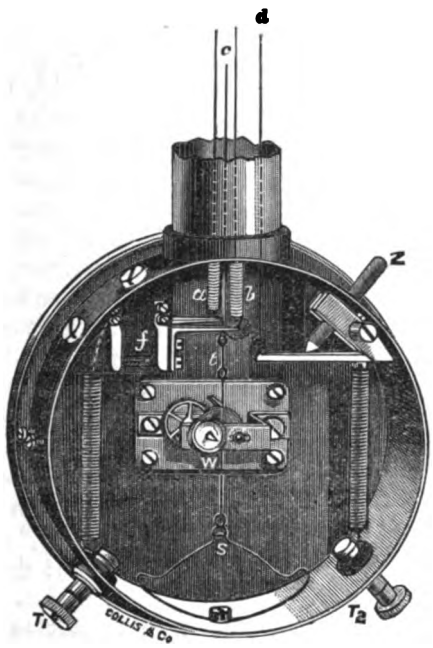
of nearly 3ft. of ·0025 platinum-silver wire extends to the top of the tube, where it is made fast to an insulated copper bar. This is not the working wire, but is merely employed to gain resistance. Its expansion is taken up by the German silver spring. A second length of idle wire is attached at the top to the same bar, and descends to the second German silver spring *b*. This spring is secured to an insulated brass arm supported by the vulcanised fibre block. In the figure it will be seen that this arm, although lying very close to the fuse piece *f*, is not actually connected with the latter. From the lower end of the spring *b* a small platinum spiral is led off and is connected with the lower end of the working wire *c*. This wire terminates at the bottom in a loop, and to this loop is attached a short piece of silk thread, *t*, by which it is mechanically united to a separate piece of wire. The latter wire makes a turn around the pulley W, and is finally attached to the looped spring *s*, by which, together with the working wire, it is held taut. The working wire is thus insulated from the case and from the gearing.



An Improved Cardew Voltmeter.

From the end where it is fastened to the silk thread *t* and to the idle wire *b* the wire *c* extends to the top of the tube and passes over a brass pulley insulated from the case by jewels in which it is pivoted, thence the same wire (now marked *d* in the figure) descends to the brass arm seen on the right, which is connected with the terminal T_2 by a helix of silk-covered copper wire. By the way, although it is a comparatively small point, yet since the avoidance of self-induction forms the chief *raison d'être* of the instrument, it might be as well if Messrs. Paterson and Cooper avoided the use of these helices, which are somewhat unnecessarily long and compact.

In the older types the loss of zero, after the instrument has been in use for a short time, is often a source of trouble. To avoid this the bar on the right, to which the wire *d* is attached, is hinged at the back, and a stiffly set screw, Z, bearing upon this, projects outside the case and forms a very convenient mode of adjusting the needle to zero when necessary.

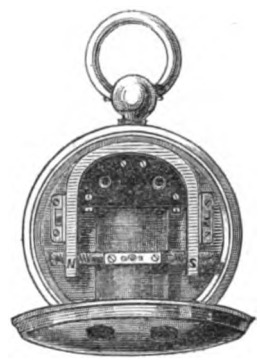
Returning to the gearing, we have seen that the wire passing round the brass pulley W is attached to the working wire by a silk thread, so that this part is entirely distinct from the electrical circuit. On the staff of the pulley is a toothed wheel, seen at the back, which gears with a small pinion upon the shaft of the pointer, and by which the extension of the wire is considerably magnified. The movement of the pointer is made against a hair spring, which keeps the pinion teeth always hard against the wheel teeth and so prevents back lash. All the *pivots* are end stone jewelled, so that the friction of the instrument is very slight.

It may be added that the object of putting the additional resistance in the form of fine stretched wire is not only to avoid self-induction, but also to obtain a more rapid cooling after being used for high E.M.F.'s.

We have only to add that the workmanship and finish of the instrument are excellent throughout.

A POCKET VOLTMETER.

The adjoining illustration represents a nickel-cased pocket voltmeter, and is drawn to a scale of one-half the actual size. The instrument is about the same dimension and shape as an old-fashioned turnip watch, and is shown in the figure with the case open at the back. It will be seen that the construction is of the Ayrton and Perry permanent magnet type. Connection is made without opening the case by pushing the wires through two small holes in the cover (these holes can be seen in the figure). The wires are then gripped by a spring catch, which secures a firm contact. On the front of the case is a glass-covered dial, upon which the pointer indicates the volts, the calibration being for direct reading. The needle is mounted upon a pivot working on jewels. The instrument from which

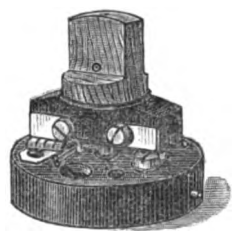


Pocket Voltmeter. (Half size.)

our illustration was drawn weighs just 6oz., and is calibrated up to 40 volts. The scale is of sufficient size to enable one volt to be read with ease, and we understand that they are made of the same dimensions, but with different winding, to read up to 120 volts. Messrs. Paterson and Cooper are the makers.

COMBINED SWITCH AND FUSE BLOCK.

The adjoining figure shows a neat and simple form of combined lamp switch and fuse block. The switch is of the bridge type,



A Combined Switch and Fuse Block.

rubbing contact being made on both sides, and pressure is secured by forming the lower contact plates of brass pieces bent twice at right angles under screws at each end. The fuse is placed between the two screws shown upon the front of the bridge. A stout steel wire throw-off is provided. This switch is made by the United Electrical Company, Albert Embankment, S.E.

MICA.—The use of mica for electrical purposes has led to a very distinct increase in the demand, and special machinery has lately been devised for getting out the mineral. Some specimens of mica contain iron in sufficient quantity to affect their insulating properties. The whitest kind is usually the best. In Boston several firms are now giving special attention to the preparation of this mineral for electrical apparatus.

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THE ELECTRICIAN.

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THE TECHNICAL EDUCATION BILL.

Whatever may have been the motive of the Government in rescuing this Bill, with several others of greater or less importance, from the massacre which usually overtakes the innocents at the fag end of a session, we are disposed to accept the fact with some satisfaction, if not exactly with pride. The Bill is not one to boast about; but neither is the outcry which has led to its introduction. And in view of the vehement demand for governmental encouragement of Technical Education—a demand which has been fostered by high professional and scientific authority—it is well that some step should be taken to put the matter to a practical test; and for this purpose Sir W. HART DYKE'S scheme is probably as good as any other. We hope, therefore, that nothing may occur to hinder the Government fulfilling their intention in respect to this particular experiment, not because much good can come of it, but because it will enable us the better to judge on independent testimony whether in reality the shortcomings of our industrial system are due to its deficiency in technical knowledge. Those who have been most confident in asserting this as a fact are not wholly disinterested witnesses, and the response to the invitation embodied in the Government Bill, the acceptance of which is everywhere optional, will be a far safer criterion to argue upon. Any given locality may be supposed to know its own wants best, and the local authorities, who alone can set its machinery in motion, are pretty certain to adopt the Bill if it is wanted.

If, on the other hand, the local authorities do not adopt the Bill, we may conclude that in their judgment its provisions would have no beneficial effect on the local industry. The poll which it is necessary to invoke before carrying out their resolution is sure to be in favour of the promoters. School Board as well as Municipal electorates are largely composed of persons who rejoice in getting their children educated at the expense of the minority, and who are not at all likely to scruple about charging another *ism* to the same account. The decision, we repeat, will virtually rest with the representatives of local trades and manufactures, whose well-informed opinion upon the value of this Bill we shall await with much curiosity. They certainly will not be allowed to treat it as non-existent. The Science and Art Department has a direct interest under the provisions of the Bill; and we are sure the Science and Art Department will not lose such an opportunity of expanding its operations. It will prescribe the subjects of instruction, or, at all events, the standards of proficiency; it will, or may, get its own technical schools "combined" with the Board Schools; and it is easy to see that before long the Science and Art Department would have the control of the whole business. Indeed, in practical operation, it seems to us that the school rates may very easily be diverted so as to constitute a subsidy to the Science and Art Department. Again, the managers of any technical schools in the district of a local authority may, under Clause 7 (1), make an arrangement with the local authority for transferring their schools to that authority, which is a further extension of the methods already pursued for extinguishing voluntary schools and throwing the cost of maintaining them on the rates. Thus, there will be no lack of incentive to prompt the local authority to "do their duty"; and it will be strange, indeed, if they resist the pressure.

The powers given under the Act are sufficiently liberal. With the permission of the electorate the local authority may provide separate technical schools for its district, or combine with any other local authority for providing such schools common to the districts of both authorities; or it may contribute to the maintenance, or provision and maintenance, of any technical school; or it may make what other arrangements it sees fit for supplementing, by technical instruction, the ordinary instruction given in any public elementary school in its district. With a view to economy, two or more local authorities may combine for the purpose of carrying out the Act; but this must be with the sanction of the Science and Art Department—a sanction the necessity for which we entirely fail to see, that august body having no interest whatever, but rather the reverse, in sparing the pockets of the local ratepayers. As regards the technical instruction, it is defined as being in the branches of science and art, with respect to which grants are made by the "Department of Science and Art," or "in any other subject which may be sanctioned by that department." It will be seen, therefore, that although considerable latitude is allowed to the local authority in respect to ways and means, its ideas of what kind of technical instruction is required in its district will have to conform to those of South Kensington. This is to be regretted; but London is not included in the Act, or, more correctly, the machinery for applying it there is different; and possibly the provincial mind, knowing less of South Kensington than Londoners do, may hold its authority in higher esteem.

At the first blush, however, "branches of science and art" are not calculated to inspire even the "local authority," we should imagine, with much confidence in their efficiency as a remedy for stagnation in trade. It is to be hoped that the term "in any other subjects" may be broadly interpreted by all the parties concerned. Science and art have their technicalities truly; but science and art do not necessarily include technical instruction—at all events not exactly of the kind which boys attending Board Schools are in need of to get their own living by, and to elevate the character of British workmanship. But perhaps this is not what the prime authors of the Bill are aiming at. We ourselves have never seen a clear statement of what they do aim at. One may, however, hazard a conjecture from the Schedule appended to this Bill. Payment out of the local rates is to be made in respect to no scholar unless or until he has passed the sixth standard; and from the Schedule we gather that before a scholar can be technically instructed—or before his instruction can be paid for, which is, or ought to be, the same thing—he must be able not only to read Shakspeare, write a theme or letter on an easy

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subject, the spelling, handwriting, and composition of which must satisfy the examiner, but also to pass in arithmetic to the tune of "fractions vulgar and decimal, simple proportion and simple interest." Now, assuming that the technical instruction is going to be a useful reality, it passes one's comprehension to understand why boys who have not learnt these three very big R's should be prevented learning the utilities of their future trade or handicraft. Logically, they are the lads who will depend more on their trade than on the three R's, little or big, and therefore need technical instruction most. But, after all, we do not presume to know for whose benefit precisely the "science and art" is to be given; and we can only desire that the experiment may be speedily tried, and hope that everybody will be satisfied.

CORRESPONDENCE.

NON-POLAR DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have a private letter before me now, touching this correspondence, in which the writer calls attention to a statement by Mr. Preece respecting the inductive effect of a telegraph conductor at Newcastle sensibly affecting another conductor at Darlington, this being, apparently, an argument to convince me of the difficulty of arranging a conductor in a magnetic field without its being influenced thereby. And Mr. Thompson thinks it would be necessary "to construct a pivot conforming with Euclid's definition of a line to get the conductor outside the field without cutting some of the lines of force." Mr. Thompson has laid hold of a misplaced word. I certainly said that by arranging the wire from the pivot in a direction parallel with the axis of the magnet it would be "totally" out of the field. I ought to have said *practically* so. But I would appeal to him and your readers, having regard for the actual and known distribution of lines emanating from a bar magnet, whether such a conductor so placed would not be practically out of the field. It will perhaps be remembered that I took Mr. Thompson on his own ground by examining this question from his own point of view by showing an experiment with both poles of the magnet. That, I submit, proves beyond all doubt that the magnet itself is the movable conductor, while the magnetism is a fixed element. If it were not so the output of current would be the same whether one or both poles were acted upon. I notice Mr. Thompson is silent on this point. I admit that my theory stands or falls by this one experiment. Mr. Snowden asks if the result 1 : 2 was only a prediction on my part; I may say that it was a prediction roughly verified by experiment. I do not say that the result would be practically 1:2, but theoretically so. There is the extra resistance of wire to be taken into account when the two poles are used. Mr. Thompson further informs us that a Gramme ring does not revolve easily in a magnetic field. But the question I asked in my last letter was this:—"Why should not a bar magnet rotate axially through the magnetism as easily as the Gramme ring revolves longitudinally through it?" I said this on the understanding that both were opposed to a mechanical resistance. But why this resistance? That is the question. When a mass of iron is moved in a magnetic field currents are produced in it transversely to the direction of such movement by reason of conductivity, and the mechanical resistance is caused, not by the difficulty of iron passing through the lines of force, but by another kind of force—electricity—being formed in it, which acts on the magnetism. If iron were a non-conductor of electricity it would rotate in the field as easily as a piece of vulcanite. But, says Mr. Thompson, "Why have a core at all?" The advantages of an iron core would appear from the fact that it deflects or concentrates the polar direction of the magnetism or lines of force into the most favourable position to be mechanically acted upon by a movable conductor. In a Gramme ring without an iron core the inside coils would develop an opposing E.M.F. that would be only less than that of the outside coils, as the speed would be less in revolving. The advantage of an iron core in the Siemens armature is not so apparent.—Yours, &c., E. L. VOICE.

6, Betterton-street, Endell-street, W.C.,
August 1st, 1887.

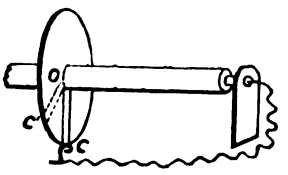
TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorry that Mr. Snowdon should give me credit for a statement so absurd as that a "a cylindrical magnet rotated on its axis does not excite a current in a stationary conductor situate in its field, while the conductor itself, if rotated in the same way relatively to the magnet, does give a current." The former statement is, of course, quite accurate; the latter is inconsistent with both theory and experiment, and on looking over my letter again, I can see nothing which can have suggested that I entertained such a ridiculous idea.

What I *do* emphatically assert (even at the risk of being stigmatised by Mr. Voice as behind the times) is that no induced E.M.F. is possible in a circuit without a change in the number of lines of force embraced by the circuit—that is, without the cutting by a conductor of lines of force. This "out-of-date theory," otherwise stated, simply affirms that the variation of energy of an electro-magnetic system is proportional to the work expended in deforming it against the electro magnetic forces; and this, again, is a necessary and immediate consequence of the principle (which possibly Mr. Voice considers a relic of antiquity) of the conservation of energy. I have not, unfortunately, access to the copy of *The Electrician* referred to by Mr. Voice; but if he was there successful in upsetting this principle, I venture to say that he brought forward stronger evidence than the experiment of the rotating magnet, and offered a better substitute for the "out-of-date theory" than the explanation (to call it so) which he gives. Unfortunately, this "explanation" is inconsistent with facts, and can be shown to be so by a very simple modification of the apparatus shown in Mr. Voice's diagram.

Mr. Voice says, "Let another conductor be in contact with the other pivot at B, and joined to that leading from A, as in the accompanying figure. The speed of the magnet being the same, the resultant will now equal 2, just double." I hope, for his own sake, that Mr. Voice means us to understand that we shall get double *E.M.F.*, and not double *current*, as one would naturally infer from his language; the strength of the *current* of course depends on the *resistances* of the two circuits.

However, even if Mr. Voice does mean that the E.M.F. is doubled, he is wrong. The speed being the same, the E.M.F. will be the same whether the point C (in Mr. Voice's figure) be joined to the pivot A or to the pivot B, or to both. A galvanometer inserted between the point C and the rubbing contact on the disc will show different deflections in the two cases, or the same according to the values of the resistances in circuit. If, for instance, the resistance of the galvanometer is equal to that of the wire from C to A, and to that of the wire from C to B, the galvanometer deflections will in the two cases (one circuit closed, and both closed) be in the ratio of 3:4.



By a suitable arrangement of the resistances the current may be doubled, but the E.M.F. only by altering the speed.

The real explanation of the production of the E.M.F. is, in reality, a simple matter. If we consider the circuit formed by the half length of the magnet, a *radial element of the disc*, and the outside connections (which for simplicity, though it does not affect the argument, we consider as lying in the vertical plane), we have initially the whole circuit in the vertical plane through the axis of the magnet, as in the figure, and no lines of force pass through the circuit.

But after the magnet has rotated through a portion of a turn we have the state of things seen by the dotted line CC^1

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The radial element of the disc originally at C has passed to C^1, the rest of the circuit remains as before in the vertical plane through the axis; but the portion O C^1 C is now perpendicular to the axis, and encloses a number of lines of force which vary from zero to a maximum and back again to zero at every revolution. An electromotive force is therefore induced, quite as it should be on the "out-of-date theory."

Mr. Snowdon's idea that the lines of force do rotate (at least unless when prevented by external forces) might, I think, easily be put to the test of experiment.

For a free magnet pole, *e.g.*, a positive pole placed near the magnet, would of course at once move along a line of force to the negative pole of the magnet. Now, if this line of force were rotating round the axis of the magnet, the free pole would share the rotatory movement, and as the result of the combination of the two motions would follow a sort of helical curve terminating at the negative pole of the magnet.

Similarly, a free negative pole would take a corresponding movement, terminating at the positive pole of the magnet. Hence, if a small magnetised needle were brought near the rotating magnet, the movements in opposite directions of each of its poles towards those of the magnet would neutralise each other, but the movements of rotation, being in the same sense in each case, would remain. Hence, the needle, if free to move bodily, would rotate round the axis of the magnet. Such an experiment might, I think, be easily devised. For example, the needle, pivoted vertically, might float on the surface of water in an annular trough, in the centre of which the magnet would rotate on a vertical axis.

Both Mr. Snowdon and Mr. Voice have, I think, rather complicated the discussion by confusing (at least in their language) magnetism and magnetic force, and assuming that magnetism exists necessarily in the medium surrounding a magnetic body. *Magnetic force*, and not *magnetism*, is what exists in the field of a magnet; and to talk of force possessing "inertia," infinite or otherwise, seems to me to be going rather far.—Yours, &c.,

BERNARD P. SCATTERGOOD.

Park-square, Leeds.

ESTIMATES FOR ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been following with much interest the letters that have appeared on "Estimates for Electric Lighting." I quite agree with Mr. Money-Kent that the Electric Lighting Act of 1882 has not been the sole cause of the slow progress of electric lighting.

In many cases this slowness can be traced to men who have undertaken the erection of installations without having a sufficient knowledge of practical engineering—leaving their knowledge of electricity out of the question altogether; men who have not been able to estimate whether an engine they inspected was capable of doing the work required or not.

Now, I venture to think that it is necessary not only that a good knowledge of the laws of electricity should be acquired, but also that every electrical engineer should be a *practical* engineer apart from all else, in order that he may safely judge of what is and what is not required in the estimating and successful carrying out of an installation. Again, what egregious blunders one sees in the estimating of the number of lamps to light a certain area, the size of cable to be used for certain work, &c. This would not be if those who tender were thoroughly practical men.

I scarcely think that Plonmel's figures can be carried out in practice, because buildings vary so much in shape and form, and in all cases the light is not required to be uniform.

For instance, a place of entertainment requires the light concentrating more particularly on the platform, as was the case here two years ago when the National Eisteddfod held their annual meeting. And here we will have a word about tenders and consulting electrical engineers.

I was called in by the committee of the Eisteddfod to give my opinion as to the number of lights required to light the pavilion (the area of which was 21,312 square feet), and also to advise as to the disposition of the lamps. I estimated that it would take 177 16 candle-power lamps to light it brilliantly, but under the circumstances 133 might do, as most of the light was required near the platform.

Tenders were invited, but no specifications given. Only two were received; one from a branch of one of the largest companies in the kingdom, and the other from a private firm. The former proposed seven 1,200 candle-power arc lamps inside and three outside; the latter sixty 16 candle-power incandescent inside and three arc lamps outside—a most remarkable difference in the candle-power estimated. Cost of former company to be £58; cost of latter to be £27. 10s. I pointed out to the committee that the light would be perfectly inadequate if they used only sixty 16 candle-power lamps; but they were assured, on the other hand, that the firm would guarantee them sufficient light. It ended thus:—The committee put a gang of men to work on Sunday to get the gas in, thus bringing the profession of electrical engineering into contempt, and making "electric light" a bye word for darkness.

I could mention many other things; but I think I have said sufficient to show that a knowledge of practical engineering is indispensable; that a perfect knowledge of the area a lamp will light satisfactorily is required; that the lowest tender is not always the cheapest; and that a consulting electrical engineer is not always thought to be right when those who are employing him, or asking his advice, think they know the most, or are afraid to go to the necessary cost to do the work properly.—Yours, &c.,

G. WILSON.

Aberdare, August 2nd, 1887.

A NEW EDISON SYSTEM OF DISTRIBUTION.*

It has come to be recognised that if high-tension currents can be employed for electric lighting and other purposes, with the economy in copper which they permit of, but without bringing the wires carrying the high potentials within buildings where they are subjected to handling, and where contact with them is liable to lead to accident, the scope of electrical distribution would be greatly enlarged. The endeavour to accomplish this object has given rise to a number of systems of late, most of which have been based on the alternating or interrupted current and the transformer to reduce the potential from the distributing wire to the house wire.

In order to achieve the same object with the continuous current Mr. Edison has recently devised a system in which a high-tension circuit is employed, and which may in a certain sense be called a multiple-series system on a large scale, with special arrangements for keeping the potentials in each multiple branch constant. In carrying out his idea, Mr. Edison uses a divided source of electricity of high tension consisting of two or more dynamos connected in series placed in a suitable building at a place where power may be produced economically. A circuit extends from this source of power to the various sub-stations, at each of which feeding circuits are taken off, which extend to a district to be supplied with current. All these sub-stations are in series, and from the main circuit conductor between the stations compensation conductors extend, which are connected with the points of division of the source of supply.

At each sub-station indicators and regulators are provided by means of which the electrical condition of the circuits extending from them is indicated and regulated, and from each sub-section a circuit extends to the main station or source of supply, with which circuits are connected indicators, in accordance with whose indication the generators are regulated according to the requirements of the distance supplied from each sub-station.

In the diagram the system is shown in which the districts are arranged on the three-wire system, but the arrangement is equally applicable to the two-wire system.

The method is particularly applicable to cases where there is a very large area to be lighted or supplied with current from a single source.

In the Figs. A, A^1, A^2 and A^3 are dynamos all connected in

* From the New York *Electrical World*.

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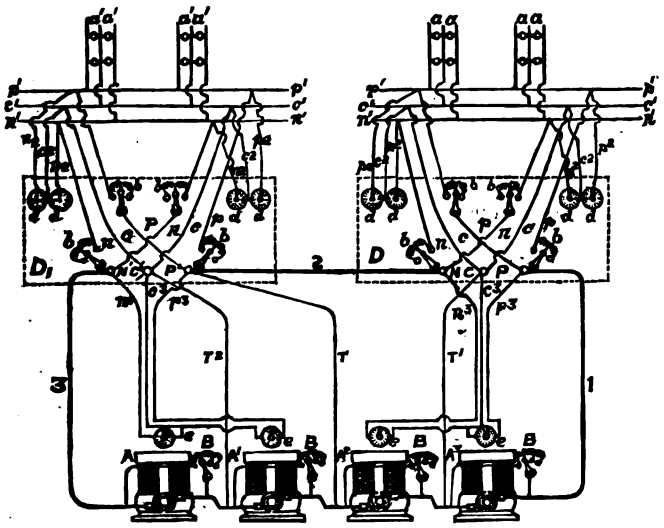
series and situated at a point where the necessary power to operate them can be cheaply produced, and which may be for that purpose situated, if necessary, at a considerable distance from the places to be supplied, since the current generated by the series of machines has a high tension, and can therefore be economically conveyed by conductors of small mass. Each generator can be regulated separately by means of the adjustable resistances B B, placed in the shunt field circuit of each machine.

From the terminals of the series of machines a circuit, 1, 2, 3, is extended to D and D^1, which represent sub-stations to which the circuit extends. The dotted rectangles indicate rooms or places into which the conductors are run, and in which the connections are made and the indicators and regulators are placed. In the station P the conductor 1 is brought to a positive terminal point, P, and from a negative terminal point, N, the conductor 2 extends to the next sub-section, and there is also a third terminal point, C. From the sub-station extend two feeding circuits *p*, *n*, *c*. The conductors *p* extend from terminal N, and conductors *c* from terminal C, and these conductors are all connected respectively with the positive, negative, and compensating circuit conductors *p' n' c'*, with which the lamps *a a* are connected in multiple series on the three-wire system.

Each of the feeding conductors *p*, *n*, is provided with an adjustable resistance *b b*, by which the two sides of the sub-system are regulated to keep the same constant pressure at all points on the lighting circuits, thus regulating for unequal distribution or changes in the number of lamps in circuit. This regulation is effected in accordance with the showing of indi-



cators *d d*, connected across the conductors of three-wire indicating circuits $p^2 n^2 c^2$, one of which extends back from the terminals of each feeding-circuit into the sub-station, and which continually show the pressure at the points where the feeders are connected. The sub-station D' is similarly arranged and equipped, the conductor 2 being carried to the terminal point P' and the conductor 3 from the main source to the terminal N', and the feeders extending from terminals P', N', and C', and supplying lamps *a' a'*, and provided with indicating and regulating apparatus precisely as explained with reference to the other station. It will be seen that the conductor 2 connects the two districts supplied from the two sub-stations in series with each other, and with the generators at the main station. From any point on the conductor 2 between the sub-stations a conductor T extends to the middle point of the series of generators, by which a divided source of electricity is produced, at whose point of division the compensating conductor T is connected. The conductor T is shown as extending from the terminal point P' in sub-station D'. The effect is evidently the same as though it were connected anywhere along the line 2 between the sub-stations.

From the terminal point C in station D a conductor, T', extends, which is connected between the generators A^2 and A^3—that is, at the middle point of one of the divisions of the source—and from C' in station D' a similar conductor, T^2, extends and is connected between generators A and A', the two divisions of the source being thus themselves divided, or, in other words, the source being thus subdivided into four sub-divisions. Thus the two districts form a compensating or three-wire system, having a divided source and a compensating conductor, while each district is itself a three-wire system having a divided source and a compensating conductor. The lamps of the two districts are in multiple series with each other—that is, any two lamps, *a a* in series in district D, are in series with two other lamps, *a' a'*, in district D'. There are, therefore, four lamps in series, and hence high-tension currents and small conductors are employed. At the same time, all the lamps are independent. In each sub-system, when the number of lamps on the two sides becomes unequal, current flows in one direction or the other on conductors *c* and T' or T^2 to maintain the balance, and if the number of lamps in one sub-system differs from that in the other the balance is similarly preserved by the compensating conductor T.

As stated, the adjustable resistances at the sub-stations are employed to keep a constant pressure at all feeder terminals, thus regulating for unequal distribution or changes in the number of lamps in circuit in different parts of the district. Indicating circuits also extend from the sub-stations to the main station, each of which consists of three conductors, p^3 n^3 c^3, including indicators *e e*, by means of which the condition of each side of each sub-system is continually shown, and in accordance with which the generators are regulated together or separately to regulate the whole current supplied to the entire system, or that supplied to each sub-system or that supplied to each side of each sub-system. It is evident that there may be any desir d number of sub-stations and districts supplied, the number of generators at the station being correspondingly increased, so that there will be one or more generators for each side of the sub-system, and conductors being run from between the sub-stations to the points of division, and from the middle terminals of the sub-stations to the poin's of subdivision of the source. The generators comprising the high-tension source need not necessarily all be placed in the same building or at the same place; but they may be placed at two or more different points, they being, however, always connected in series by conductors extending between the different points.

In the system above described economy is attained not only in conductors but in other ways also, in the matter of renting or purchasing property for stations, for instance; for the main station may be placed at a distance from the thickly settled areas to be illuminated, at a point where rents are low or property cheap, while for each of the sub-stations only a small room is necessary, which can be cheaply obtained, it being necessary only to have room enough for the indicators and adjustable resistances. A single attendant is kept at each sub-station, whose only duty is to observe the indicators and adjust the resistances accordingly.

THE BRUSSELS 1888 INTERNATIONAL EXHIBITION.

The following is the schedule of the electrical section of this exhibition under which the prizes and medals are to be awarded:—

Sub-division 47a.—President: ERNEST ROUSSEAU.—"The study and instruction of electrical science; instruments of measurement; scientific application of electricity; lightning conductors and lightning protectors."—1. Lightning conductors. 2. Processes of testing a lightning conductor. 3. Means of ascertaining the value of a battery. 4. Laboratory tests of a conductor intended for an overhead line. 5. Instrument or means of measuring telephonic currents. 6. Treatises on the science or application of electricity. 7. Industrial ampere-meters for continuous currents. 8. Industrial ampere-meters for alternating currents. 9. Industrial voltmeters for continuous currents. 10. Industrial voltmeters for alternating currents. 11. Ampere-hour meters. 12. Watt meters. 13. Collection of measuring instruments for laboratories. 14. Measuring apparatus constructed on a new principle, or exhibiting an improvement on existing apparatus. 15. Photometry by means of electricity. 16. Apparatus for measuring power absorbed by magneto or dynamo machines.

Sub-division 47b.—President: M. F. DELARGE.—"Motors and dynamo electrical machines; transmission of motive power to a distance; distribution of electrical energy, transformers."—17. (*a*) Electric light dynamos, output not exceeding 2,000 watts; (*b*) ditto, not exceeding 10,000 watts;

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(c) ditto, not exceeding 10,000 watts; (d) dynamo machines for light-houses; (e) dynamos to replace batteries in telegraph offices. 13. (a) Transmission of motive power to a distance, &c.; (b) systems of distributing electrical energy.

Sub-division 47c.—President: M. BANNEUX.—"Telegraphy, telephony, wires, and cables."—19. The most practical system of light lines and apparatus (either telegraphic or telephonic) for communicating with out-posts. 20. Insulators (a) for telegraph lines; (b) for telephone lines. 21. Overhead conductors (a) for telegraph lines; (b) for telephone lines. 22. Metallic posts for lines (a) in the open country; (b) in towns. 23. Systems for preservation of wooden posts. 24. Stays and struts (metallic) for posts. 25. Submarine cables (a) for telegraph lines; (b) for telephones. 26. Lightning protectors 27. Telephones; (a) for private lines; (b) for public service. 28. Microphones; (a) for private lines; (b) for public service. 29. Telephone exchanges; (a) for private lines; (b) for public service. 30. Simultaneous telegraphy and telephony on one wire. 31. Multiplex telephony. 32. Commutators for telegraph lines. 33. Telegraph apparatus for offices of moderate importance. 34. Fast-speed telegraph apparatus for single transmission. 35. Telegraph apparatus, multiple transmission. 36. Apparatus for working submarine cables of large capacity. 37. Relays. 38. Telegraph calls. 39. Remedies for induction on telephone lines. 40. Systems of telephone stations connected on a single line wire with either earth or wire returns. (The stations must be able to communicate with each other, and also through a central exchange with other lines.) 41. Automatic telephone exchange apparatus. 42. Telephone relays. 43. Means of connecting a metallic circuit line with an earth return line. 44. Protection of insulated cables from fire. 45. Means of preventing the abnormal heating of conductors.

Sub-division 47d.—President: M. WYBAUX.—"Arc and incandescent lamps."—46. Arc lamps (a) of great power; (b) of moderate power, 500 to 2,000 candles (c) of low power; (d) arc light carbons. 47. Incandescent lamps. 48. Electric lamps of any other type. 49. (a) Systems of lighting mines, submarine lamps, &c., (b) portable lamps. 50. Supports for public lamps.

Sub-division 47e.—President: M. WAFFELAERT.—"Batteries, accumulators, various industrial applications, electro-chemistry, electro-metallurgy, railway signals, &c., &c."—51. Batteries for telegraphs; (a) continuous currents; (b) intermittent currents. 52. Batteries for telephones. 53 Ditto for movable telegraph stations. 54. Dry batteries. 55 Batteries for domestic electric lighting. 56. Thermo-electric piles; (a) for domestic electric lighting; (b) for other purposes. 57. Batteries for lighting sailing ships. 58. Accumulators. 59. Electric clocks and systems of distributing time. 60. (a) Apparatus for indicating temperature at a distance; (b) automatic fire alarms; (c) public fire alarms. 61. Speed regulators. 62. Extracting metals from their ores. 63. Processes of working metals. 64. Applications of electricity to industrial chemistry. 65. Applications to railroads; (a) communication with moving trains; (b) intercommunication on trains. 66. (a) Applications to the block system; (b) actuating signals at a distance; (c) applications to interlocking systems; (d) actuating barriers at a distance. 67. Electric breaks. 68. Indicators of position of trains and other similar applications, such as indicators of water level. 69 (a) Lighting trains; (b) heating trains. 70. Electric traction; (a) by accumulators; (b) from fixed stations, by existing rails, by a special rail, by overhead conductors; (c) on primary and secondary lines, and on tramways; (d) telpherage. 71. Registering variations of velocity of a motor. 72. Electric governors. 73. Firing shots in mines; (a) by high-tension fuses; (b) by mean tension; (c) by low tension. 74. (a) Electric rifles; (b) firing artillery; (c) training artillery. 75. Electric torpedoes, fixed; torpedoes steered or propelled by electricity. 76. A prize is offered for the most remarkable invention in electricity not coming under any of the above heads.

DESCRIPTION OF THE ELECTRIC LIGHT ON THE ISLE OF MAY.*

BY DAVID A. STEVENSON, B. SC., F.R.S.E, M. INST. C.E.

The lighthouse situated on the Isle of May, at the mouth of the Firth of Forth, has recently been lighted with electricity; and as this light, besides being, the author believes, the most powerful in the world, possesses several novel features, he has the pleasure of offering the following notes regarding it, trusting that they will prove of interest in connection with the visit to be made to the lighthouse on the occasion of the present meeting.

The Isle of May was originally lighted in 1636 with an open coal fire. In 1816 the Commissioners of Northern Lighthouses, having previously purchased the island with the right to levy tolls for the lighthouse, altered the light to argand lamps with silvered parabolic reflectors. In 1836 it was converted to the dioptric system, with a first order fixed light apparatus, and a four-wick burner; and on 1st December, 1886, the electric light was substituted, and shown in connection with a dioptric condensing apparatus. For the last fifteen years the Commissioners of Northern Lighthouses, acting under the advice of their engineers, Messrs. Stevenson, had been anxious to establish an electric light on the Scottish coast; but it was not till 1883 that the Board of Trade were able to sanction the expenditure, and suggested its introduction at the Isle of May on the ground that "there was no more important station on the Scottish shores, whether considered as a landfall, as a light for the guidance of the extensive or important trade of the neighbouring coast, or as a light to lead into the refuge harbour of the Forth."

Notwithstanding the difficult access and isolated position of the Isle of May, distant five miles from the Fife shore, which is the nearest land, it was resolved to accept the view of the Board of Trade, and to introduce the electric light there. The necessary plans and specifications were accordingly prepared by Messrs. Stevenson; and the works, begun in June, 1885, were completed, and the new light installed by 1st December, 1886.

It was originally intended by Messrs. Stevenson to use the Brush compound-wound Victoria dynamo, giving a continuous current, and supplying a single automatically fed arc lamp with the positive carbon *below*. This system was selected as being at once cheaper, and as giving a stronger light-power for the engine-power applied, than the magneto-electric machines, which had hitherto, with success at least, been exclusively used in lighthouses. The placing of the positive carbon below was adopted in order that the strongest light might be thrown upwards, so as to be dealt with by the upper part of the dioptric apparatus, and thus be more effectively utilised. The Brush Company at once set to work to produce a lamp of the above description, giving, with a current of 100 amperes and 70 volts, a light of 30,000 candle-power in the horizontal line, steady and suitable for burning in a lighthouse. This unfortunately they were unable to accomplish, even after numerous trials; and at last, as the buildings on the island were nearly completed and it became necessary at once to procure reliable apparatus, recourse was had to the more expensive alternate-current machines of De Meritens, which, though not so powerful, are admirably steady in working, and had given excellent results in several lighthouses, and also at the South Foreland experiments.

The generators at the Isle of May are two of De Meritens' alternate-current magneto electric machines of the L type, and are of the largest size hitherto constructed, weighing about 4½ tons each. The induction arrangement of each machine consists of five sets of twelve permanent magnets, sixty in all; and each magnet is made up of eight steel plates. The armature, 2ft. 6in. diameter, is composed of five rings with 24 bobbins on each, arranged in groups of four in tension and six in quantity; it makes 600 revolutions per minute.

With the circuit open each machine develops an electromotive force of 80 volts measured at the distributor, and with the circuit closed through an arc 40 volts. An average current of 220 amperes is developed, thus yielding an electrical energy of 8,800 watts, or 11·7 horse-power in the external circuit. The five rings are so arranged that one-fifth, two-fifths, three-fifths, four-fifths, or the whole of the current of a machine can at pleasure be sent to the distributor for transmission to the lantern; and, further, the two machines can be coupled, and the full current from both be employed. The machines are placed in the engine room bolted down to concrete foundations, and driven from a counter-shaft.

The engines are a pair of horizontal surface-condensing steam engines, each with two cylinders of 9 inches diameter and 18 inches stroke, making 140 revolutions per minute, and each indicating 17·7 horse-power with 40lb. steam pressure above atmosphere and 11lb. vacuum. To provide against accident or failure of water supply, they have been arranged so as to be capable of being worked either condensing or non-condensing. Either of them is sufficient to drive one machine, the other engine being idle; or the two can be used together for driving both machines in thick weather. The steam to both cylinders is regulated by an equilibrium throttle-valve, which is controlled by a high-speed governor, adjusted for the engine to run at the normal speed of 140 revolutions per minute. Single, in place of compound, engines were adopted, because they are less complicated and better suited for the less skilled attendance of ordinary lightkeepers. Probably also greater regularity in driving has thus been secured, which is of course a matter of the greatest importance in electric lighting, especially where, as is the case, there is only a single arc-lamp in the circuit forming the resistance. The result has been eminently satisfactory; and the engines, which were built by Messrs. Umpherston, of Leith, are a most excellent piece of work.

There are two steam boilers, of which only one is in use at a time, the other being spare. Each is 20ft. long, and 5ft. 6in. diameter, with one furnace flue 3ft. diameter and 8ft. long, having six cross Galloway water tubes. The shells are of best best ⅜in. steel plates, with the longitudinal joints double riveted; and they were tested up to 110lb. per square inch, the working pressure being 40lb. The feed is principally rain water collected from the roofs and the pavement of the court; but water can, if required, be taken from the small loch, which is also used for condensing purposes. The coal consumption is 1 cwt. per hour of lighting, which includes banking the fires during the day.

The current generated in the engine room is conveyed to the lantern by leads, which consist of copper rods of 25 millimetres or 1in. diameter, covered with a double waterproof wrapper. This is the first time that copper rods have been used for conducting the current for lighthouse illumination. They are constructed in 14ft. lengths, the joints being formed with a zigzag scarf screwed up tightly by gunmetal coupling-boxes with four bolts in each. They are carried by timber bearers, placed in a groove made for them in the side of a concrete wall running from the engine room to the tower. The total distance to the lantern is 880ft. Several bends are introduced to allow for expansion and contraction due to changes of temperature. The loss in the leads was expected not to exceed one-sixth of the total energy generated; but it is considerably more than this, amounting to at least one-fifth.

The lamps, of which there are three, one in use and two spare, are of the Serrin-Berjot type, with some modifications—notably, the shunt or bye-pass, first introduced in the South Foreland experiments on the suggestion of Dr. Hopkinson, whereby a large percentage of the current goes direct to the lower carbon, and only an amount sufficient to regulate the carbons is passed through the lamp. This is a great improvement, and prevents injury to the lamp from heating. The weak point about it, in the lamps sent to the Isle of May, was that the contact between the lower carbon-holder and the bye-pass, being necessarily a sliding contact, was

* Paper read at the meeting of the Institution of Mechanical Engineers.

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effected by copper-wire brushes; and these were found to wear out rapidly. On the suggestion of Mr. Munro, the engineer in charge of the station, a simple form of mercury contact has been substituted, and works quite satisfactorily.

The carbons in use are 40 millimetres or 1·6in. diameter; but if desired 50 mm. or 2in. carbons can be used when both machines are running. They are Siemens's make, and have a soft central core of pure graphite, which has the effect of causing them to burn with greater regularity and steadiness than they otherwise would, and prevents a crater from forming and remaining at one side. The rate of consumption of the 40mm. carbons is 1¼in. per hour, or 2in. including waste. The power of the arc is estimated at 12,000 to 16,000 candles when one machine only is running.

The dioptric apparatus, which was manufactured from Messrs. Stevenson's designs by Messrs. Chance, of Birmingham, is of a novel description, the condensing principle being carried further than in any apparatus previously constructed. This principle consists in darkening certain sectors by diverting the light from them, and throwing it into the adjoining sectors so as to reinforce their light. Thus the power of the light is increased in proportion as the dark arc is increased. Although interesting we must pass rapidly over this portion of the paper, just mentioning that an arrangement is made for dipping the light during fog which has not yet been used; but as soon as the lightkeepers, who, with the exception of the engineer, were the ordinary keepers in the service and knew nothing of electric lighting, have become thoroughly familiar with their duties, it is intended to introduce it, and probably in the same way to employ a less powerful current, and say 25 mm. or 1in. carbons in very clear weather; while both machines with 50 mm. or 2in. carbons will be used in very thick weather. The lamps can by a carefully designed arrangement be changed in eight seconds.

The resulting beam of light from this apparatus is about three million candles when one machine is in use, and with both machines six millions; that is, about 300 and 600 times more powerful than the old fixed oil light. When the three-wick oil lamp is put in the focus of this apparatus the emergent beam is more powerful than the old fixed oil light with a four-wick lamp, which was 9,446 candles. The light has been picked up and recognised by sailors at forty and fifty miles off, by the flashes illuminating the clouds overhead, although the geographical range of the light is only 22 miles.

The engine room is connected by telephone with the light room, and the houses of the keepers are connected by air whistles or electric bells with either the light room or the engine room.

The new buildings, engines, electric machines, lamps, &c., have cost £15,835; and the buildings, lantern, &c., previously on the island, which have been utilised, may be valued at £6,600. Thus the total cost of the installation may be taken at £22,435; and the cost of maintenance will not exceed £1,050 per annum. These figures are very moderate, considering the great power of the light, and the isolated position of the lighthouse. To compare the cost of this installation with what it would have been if oil were the illuminant, there must be added to the above £6,600 for buildings, a sum of £2,925 for the cost of the apparatus and machine, &c., making a total of £9,525, while the cost of maintenance would have been £330 per annum. Taking these figures, and adding to the maintenance 3½ per cent. on the original outlay, it is found that while the oil light would cost 3·49 shillings per hour and 0·00017 penny per candle-power per hour, the electric light costs 9·66 shillings per hour or 2¾ times more, and 0·000038 penny per candle-power, or less than one quarter of what the oil light would cost per candle-power. This is taking the electric light power of one machine.

Surprise has frequently been expressed by masters of vessels, and by residents on the neighbouring shores who live in view of the Isle of May light, that this light, which is so extremely brilliant in clear weather as to cast shadows at a distance of ten and fifteen miles, is so cut down by fog that some even go the length of believing the old oil light was better in fog. All who have experience of the electric light are quite prepared for the first part of this statement; while the last, it need hardly be said, is a mistake, inasmuch as the electric arc has been proved both by experiment in natural and artificial fog, and also by observations on existing lighthouses lighted by electricity, to be in all circumstances of weather the most penetrating. Every night at twelve o'clock the lightkeepers at St. Abbs Head, 22 miles distant, where there is a first-order flashing light and one of the most powerful oil lights in the service, observe the Isle of May light, while the keepers there also observe the St. Abbs Head light. The result of the last five months' observations is that the Isle of May light is seen one-third oftener from St. Abbs Head than the St. Abbs Head light is seen from the Isle of May. It is perfectly true, however, that the superiority which is so apparent in clear and rainy weather is very much reduced in hazy weather, and practically disappears in very dense fog. Looking to this fact and to the large first cost and annual maintenance, the author feels that the conclusion arrived at by the Trinity House is sound, namely, that electricity should be used only for important landfall lights.

If, however, the most powerful light is desired independently of cost, then the electric arc has no rival. And if the further expense is to be incurred of introducing biform, triform, quadriform, or even double quadriform lights, then the electric light is better adapted than any other illuminant, because, on account of its focal compactness and other properties, it can be so dealt with by suitably designed dioptric apparatus that the whole light evolved is effectually utilised. This is not the case with the large gas or oil flames generally used in the multiform system, in which, for this and other reasons, a considerable loss of light is incurred. Moreover, the coolness of the electric arc renders multiform lights really practicable with electricity, which can hardly be said to be the case either with gas or with oil.

The author of this paper, however, inclines to the use of hyper-radiant apparatus.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis:—

RECHERCHES SUR LA CONDUCTIBILITE GALVANIQUE DES ELECTROLYTES.*

BY SVANTÉ ARRHENIUS.

(*Continued from page 215.*)

Thus much is a meagre account of the First Part of the complete memoir. I now pass to the far more striking Second Part, and shall find it necessary to give a much fuller, and in many places verbatim, report.

I am not able to judge as to how much is original and new, as I am but slightly acquainted with work of previous writers on similar subjects, nor am I at all confident how far the hypotheses made by the author are perfectly legitimate. So far as I am able to judge, however, and making allowance for inadequacy of data and somewhat hasty generalisation, the paper seems to me to be a distinct step towards a mathematical theory of chemistry.

The title affixed to it is "The Chemical Theory of Electrolytes," but it really is an attempt at "an electrolytic theory of chemistry."

SECOND PART.

THÉORIE CHIMIQUE DES ELECTROLYTES.

89 pages. Abstract and translation by OLIVER LODGE. [*Remarks by the Abstracter in square brackets.*]

§ 1. Ammonia considered as an electrolyte.

Kohlrausch has shown that a solution of ammonia, as regards conductivity, behaves differently from all other bases. It is a much worse conductor than potash, and its exponent of dilution is not much bigger than 1 [*i.e.*, its conductivity, instead of increasing anything like so fast as concentration, scarcely increases at all]. Kohlrausch guesses that the cause of this is the prevalence of NH_3 in solution instead of NH_4HO. Probably dilution increases the supply of NH_4HO, and therefore assists conduction almost as much as it for other reasons weakens it. This would explain the peculiarly small exponent of dilution.

(14) *The conductivity of ammoniacal solution is caused by a small quantity of* NH_4HO, *which is increased by dilution.*

[I think it most rash to make definite statements like this on such a slender basis of fact.]

§ 2. Case of acids; activity.

Acetic acid has the same properties as ammonia; so has boric acid. Tartaric and oxalic have small exponents of dilution. Probably the behaviour of these acids, as well as of ammonia, is analogous to that of HCl, which only conducts in presence of water. Sulphuric, nitric, phosphoric, behave in the same way. Hence—

(15) *The aqueous solution of any hydrate* is composed of two parts besides the water, viz., an active (electrolytic) part and an inactive (non-electrolytic) part. The three constituent parts of the solution form a system in chemical equilibrium, such that dilution increases the active and diminishes the inactive portion.*

How the inactive and active portions differ is not certain, perhaps only physically. Perhaps the active part is a compound of hydrate and solvent.

To fix ideas we can introduce the notion of a coefficient of activity, defined thus:—

The coefficient of activity of an electrolyte is a number expressing the ratio of the number of ions which are really in the electrolyte, to the number of ions which it would enclose if the electrolyte were totally transformed into simple electrolytic molecules.

[This "coefficient of activity" is evidently the same thing as what, in accordance with dissociation ideas of electrolytic conduction, I called† the "dissociation ratio," *i.e.*, the relation between the number of atoms taking part in conduction to the whole number present. It may turn out that this ratio is unity, but it is in any case well to determine it, and the idea of Arrhenius that it is upon that that chemical activity and rapidity of interchange depends seems to me important.]

§ 3. Hypothesis of Williamson and Clausius, and consequences thereof.

[The continual interchanges of atoms supposed to occur among the molecules on this view of conduction are here regarded as circular electric currents. References to the original statements of the hypothesis are given as follows:—Williamson, Liebig *Ann.*, Vol. 77, p. 37 (1851); and Clausius, Pogg. *Ann*, Vol. 101, p. 347 (1857)].

§ 4. Deduction of some electro-chemical laws (16)—(20).

[*E.g.*, Faraday's laws. I omit this section because it is not much use deducing laws like these from an hypothesis. The Williamson-Clausius hypothesis is of course in harmony with the fundamental laws of the subject, otherwise it would have been pretty soon abandoned. Probably the object of the author is to show how readily the known laws can be built up from one simple foundation. One statement deduced from this hypothesis is worth quoting (*see* also *Wiedemann, Elek.*, Vol. II., p. 924).]

(20) *Every body which acts chemically by double decomposition on an electrolyte is itself an electrolyte, as well as the products of the decomposition. Therefore water, alcohol, aldehydes, &c., &c., are electrolytes and therefore conductors.*

* For "hydrate" always read *hydrogen compound, either base or acid.*

† On page 756 of last year's B. A. *Report*, Aberdeen.

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[The *a priori* manner in which this statement is made is striking ; so is the note immediately following.]

"On this subject people have disputed for some time. They often attribute the feeble conduction observed in these bodies to traces of saline impurity."

§ 5. Relation between conductivity and chemical power of acids and bases.

(21) *The molecular conductivity of the active part of an acid (in dilute solution) is constant and independent of the nature of the acid.*

For if the chemical formula of an acid is HR, its molecular conductivity, according to Kohlrausch, is $h+r$. Now the molecular conductivity of dilute salts with the same metal, MR, MR', &c., is the same ; hence $r=r'=$&c. And therefore it follows that for acids also the molecular conductivity of HR, HR', &c. is the same. A corollary is—

(22) *The more a dilute acid solution conducts, the greater is its active part.*

Similar propositions may be stated for bases.

[The author then goes on to consider the idea of coefficients of activity more particularly in the light of the Williamson-Clausius view, and he gives reasons for supposing molecular conductivity and coefficient of activity to be closely related, and indeed proportional to one another. He then says, let them be defined to be equal. A list of molecular conductivities for acids, bases, and salts from the results of Kohlrausch is supplied, and it is pointed out that the best conducting acids are the strongest. Appeal is made to the results of Berthelot, Thomson, and Ostwald in support of this.]

"Thus we believe we have proved that for acids and bases galvanic activity is accompanied by chemical activity," and probably non-electrolytes have no direct chemical action. *Cf.* Gore on the inactivity of anhydrous HCl.

§ 6. Double decomposition.

[This section is the key to the whole, and I had best translate it in full.]

Suppose two electrolytes, A B and C D, are dissolved in an inactive solvent. Circular currents pass in the solution [*i.e.* Williamson-Clausius atomic interchanges occur], whereby the bodies A D and B C are formed. If the coefficients of activity of all four bodies A B, C D, A D, and B C were equal, they would all be present in the same quantity, viz., half an equivalent of each, provided the original substances were in equivalent proportions. And in any case an equilibrium would establish itself, the rate of formation of each substance being equal to its rate of destruction. Now the coefficient of activity of a body indicates that fraction of the body which at any one time participates in the circular currents [*i.e.* is ready for interchange]. If then this coefficient for A B is α, and if m equivalents of A B exist in solution αm expresses the number of equivalents of A B which at any moment take part in the circular currents.

One could figure to oneself the process of double decomposition in the following manner. The ions of active molecules rotate round one another. Then, considering the molecules A B, the ion A moves with a certain velocity in the neighbourhood of B until it comes near another ion, B', after which it follows B'. The molecule A B exists until this happens.

As now, from the preceding, the conductivity of the active parts of all salts is the same—that is to say, according to M. Kohlrausch, the velocity with which the ions move relatively to each other is independent of the nature of the salt, and only depends on the strength of the current—it is natural enough to suppose that the said velocity is the same for all salts, even when the strength of the current is zero. [This is rather an overstraining of Kohlrausch's results, but it may pass as a first approximation any way.]

Suppose, moreover, the mean distance at which A need find itself from B' in order that it may abandon B and attach itself to B' is the same for all B ions, whatever their nature (as is probably the case in gases). In this case M. Clausius has shown that the mean path of the cation A between the moment of encountering B and B' is—

$$l=\text{const}/n,$$

where n is the number of an ion in unit volume.

True, M. Clausius has given this proof for the case where the paths are rectilinear, but according to the premisses of the demonstration it is equally valid if the path is a broken line or any other form. Suppose, for simplicity, that the B ions are motionless ; then, from what precedes, the mean time of existence of the molecules A B is—

$$t=\frac{l}{v}=\frac{\text{const}}{n\,v},$$

v being the mean velocity of an A ion. So, in unit time, of m molecules A B, a number equal to—

$$\frac{m}{t}=\mathrm{K}\,m\,n$$

are destroyed (v being the same for all electrolytes, is included in the constant K). In reality the B ions are also moving, but since v is the same for all, the only effect will be to change the constant K in such a way as to leave it, nevertheless, the same for all salts.

In the same way we can show that if p is the number of A ions, and q the number of B ions in unit vol., the number of molecules A B *formed* in unit time is

$$\mathrm{K}\,p\,q.$$

Hence the number of A B molecules at the end of unit time in excess of those at the beginning—that is to say, the velocity of the reaction by which A B is being formed—is

$$\mathrm{K}\,(p\,q-m\,n).$$

If the hypotheses supposed in the foregoing are only approximately true, the above deductions are no more so. The effect would be to multiply the number $p\,q\,m$ and n by different factors, so that the general aspect of the above-deduced expressions will be only slightly modified. The same thing can be said for the equations we deduce in the sequel. However, as in the actual state of science it is impossible to judge of the validity of these hypotheses, and as they have a certain degree of probability, and of all hypotheses are the simplest we can imagine, it is my intention to prove that the deductions which it is possible to draw from what has just been said are compatible with experimental facts—facts of which we thus give a certain explanation. But with the progress of science it is possible that one will see the necessity of modifying these hypotheses ; the general reasonings will persist nevertheless, as well as the conclusions drawn from them.

Now, suppose we have four electrolytes, A B, A D, C B, and C D, intermingled ; let the number of equivalents of each existing at a given moment be m, q, p, n, respectively, and the corresponding coefficients of activity α, β, γ, and δ, the velocity of reaction will be, according to the foregoing,

$$\mathrm{K}\{(m\alpha+q\beta)\,(m\alpha+p\gamma)-m\alpha\,(m\alpha+q\beta+p\gamma+n\delta)\},$$

an expression which transforms itself into the following :—

$$\mathrm{K}(q\beta\,.\,p\gamma-m\alpha\,.\,n\delta) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The state of equilibrium will be attained when the velocity of reaction is nothing. If then m originally equalled 1, and a quantity x of the body A B has been transformed, the final state will contain $1-x$, $n-x$, $q+x$, $p+x$, equivalents of the bodies A B, C D, A D, C B, respectively. The equation expressing equilibrium will thus be—

$$(1-x)\,(n-x)\,\alpha\,\delta=(p+x)\,(q+x)\,\beta\,\gamma \quad . \quad . \quad . \quad . \quad (2)$$

or, if p and q are zero, a case often realised in experience—

$$(1-x)\,(n-x)\,\alpha\,\delta=x^2\beta\,\gamma \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2\text{A})$$

Now introduce the following definition :— . . . Two electrolytes like A B and C D, which have no common ion, are to be called *conjugate* ; and two like A B and A D, or A B and C B, are to be called opposite.

(23) *It is pretty clear that, as soon as the relative quantities of the ions, A B C D, are given, the final result is independent of their original form of combination, whether A B and C D, or A D and C B, or any other form.*

This proposition is sufficiently natural to need no proof. Moreover, it has been verified by the work of MM. Guldberg and Waage and Ostwald.

Solving equation (2) we get—

$$x=-\frac{\alpha\,\delta\,(n+1)+\beta\,\gamma\,(q+p)}{2\,(\beta\,\gamma-\alpha\,\delta)}\pm\sqrt{\left\{\left(\frac{\alpha\,\delta\,(n+1)+\beta\,\gamma\,(q+p)}{2(\beta\,\gamma-\alpha\,\delta)}\right)^2+\frac{\alpha\,\delta\,.\,n-\beta\,\gamma\,.\,q\,p}{\beta\,\gamma-\alpha\,\delta}\right\}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or for the special case when q and p are zero—

$$x=-\frac{\alpha\,\delta\,(n+1)}{2(\beta\,\gamma-\alpha\,\delta)}\pm\sqrt{\left\{\left(\frac{\alpha\,\delta\,(n+1)}{2\,(\beta\,\gamma-\alpha\,\delta)}\right)^2+\frac{\alpha\,\delta\,.\,n}{\beta\,\gamma-\alpha\,\delta}\right\}} \quad . \quad . \quad (3\text{A})$$

The sign of the radicle is always the same as that of $\beta\,\gamma-\alpha\,\delta$.

If it should happen that $\beta\,\gamma=\alpha\,\delta$ the above solution fails, but, returning to (2), we see that in this case

$$x=\frac{n-q\,p}{q+p+n+1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3\text{B})$$

so x is always unambiguously known.

Differentiating equation (2), we get—

$$d\,x=\frac{\frac{d\,n}{n-x}+\frac{d\,(\alpha\,\delta)}{\alpha\,\delta}-\frac{d\,(\beta\,\gamma)}{\beta\,\gamma}-\frac{d\,q}{q+x}-\frac{d\,p}{p+x}}{\frac{1}{q+x}+\frac{1}{p+x}+\frac{1}{1-x}+\frac{1}{n-x}} \quad . \quad . \quad . \quad . \quad (4)$$

If, now, α, β, γ, δ are the coefficients of activity of four bodies, A B, A D, C B, C D, and if the product $\alpha\,\delta$ for two conjugate bodies is much greater than that $\beta\,\gamma$ for the two opposite bodies, one finds realised a case of very great importance, applicable to the equilibrium of four bodies, acid, base, salt, and water. According to equation (2), if the quantities mixed of acid, base, and water are 1, n, and p equivalents, there are formed x equivalents of salt and water, where—

$$(p+x)\,x=\frac{\alpha\,\delta}{\beta\,\gamma}\,(1-x)\,(n-x) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

For strong acids and bases $\alpha\,\delta/\beta\,\gamma$ is a number of several millions, while x is, from the above, always less than 1 and n : hence to satisfy the equation it is necessary that $(1-x)\,(n-x)$ shall be very small (unless p is enormous) ; that is to say, that x must be almost equal to 1 (if n is greater than 1), or to n (if n is less than 1).

(24) *If one mixes a strong acid with a strong base, they unite for the most part to a salt, in such a way that there is formed a quantity of salt always a little less than that of the hydrate of which one has added the smallest equivalent portion.*

[This is rather an anti-climax.]

The clearest way to see this is to work some numerical examples. We have therefore made calculations on mixtures of a strong base (caustic soda) with a strong acid (nitric acid) on the one hand, and of a weak base (ammonia) with a feeble acid (boracic acid, supposed monobasic) on the other. The figures employed are taken from a previous section, with the supposition that the molecular conductivity of ammonic borate is equal to that of ammonic carbonate (an hypothesis which ought to be approximately correct). We have thus calculated that if one mixes 1 equivalent of acid with n equivalents of base in 100 equivalents of water, the amount of salt formed is given in the table below for several values of n.

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1 *Nitric Acid and* n *Caustic Soda.*		1 *Boracic Acid and* n *Ammonia.*	
n	x	n	x
$\frac{1}{2}$	·4999981	$\frac{1}{2}$	·245
1	·998659	1	·404
2	·999993	2	·634
		3	·741

[The molecular conductivities used in this calculation are probably—

For HNO_3 ..... $\alpha = 3 \times 10^{-5}$ | For boracic acid ..... $\alpha = 4{\cdot}4 \times 10^{-9}$
For $NaHO$ ..... $\delta = 1{\cdot}5 \times 10^{-5}$ | For ammonia ..... $\delta = 8{\cdot}4 \times 10^{-8}$
For $NaNO_3$ ..... $\beta = 6 \times 10^{-6}$ | For ammonic borate. $\beta = 4 \times 10^{-6}$
For H_2O ..... $\gamma = 10^{-12}$ | For water ..... $\gamma = 10^{-12}$

so that $\frac{\alpha\,\delta}{\beta\,\gamma}$ in the first case equals 10^8, and in the second case equals 100, or thereabouts.]

What we have just said applies specially to the formation of salts of strong acid and base when the quantity of water is very considerable. From the above example (the formation of $NaNO_3$), as well as from proposition 24, we proceed to deduce the following observation, true for salts of strong acid and bases:—

(25) *The quantity of salt formed when one adds a strong base to a strong acid is sensibly proportioned to the quantity of base added, until the acid is saturated, after which the formation of salt sensibly ceases.*

An entirely different aspect is presented by the figures calculated for the formation of a salt from feeble constituents, such as borate of ammonium. In this case $\alpha\,\delta/\beta\,\gamma$ is not excessively great, so that for considerable quantities of water (p) it is not necessary for either $1-x$ or $n-x$ to nearly vanish. That is to say, although the acid is in excess the free portion of base is nevertheless sensible, and *vice versâ*. In this case we may apply equation (4), regarding all quantities contained in it except x and n as constant, and q (the original amount of salt) as zero. We thus find that—

$$\frac{dn}{dx} = 1 + (n-x)\left(\frac{1}{1-x} + \frac{1}{p+x} + \frac{1}{x}\right)$$

[which may be written more systematically, though less usefully for present purposes

$$\frac{dn}{dx} = \frac{n}{x} - \left[\frac{n-1}{x-1} + \frac{n+p}{x+p}\right].$$

Differentiating again we get*

$$\frac{d^2n}{dx^2} = \frac{2}{x}\,\frac{(p+1)(n-x)}{(p+x)(1-x)^2},$$

which is always positive, since x cannot be greater than n. This we can render into words thus:—

(26) *If one adds a feeble base to a feeble acid, or* vice versâ, *there is necessary for the formation of a given quantity of salt* (dx) *a quantity of base* (dn) *so much the greater as the formation of salt has proceeded further.*

Moreover, equation (4) shows that if n is greater than 1, the denominator is not very great, because $1-x$ differs sensibly from zero; so $\frac{dx}{dn}$ will have a sensible positive value even for $n > 1$, which means—

(27) *If one adds a feeble base to a feeble acid, or* vice versâ, *the formation of salt continues sensibly, even after the number of equivalents of the body added has surpassed that of the other body.*

The figures calculated for boracic acid and ammonia exhibit this property clearly. Between the two examples cited are a crowd of transitions which are realised by mixing a strong acid with a feeble base, or *vice versâ*. Everything depends on the magnitude of the factor $\alpha\,\delta/\beta\,\gamma$, and on p, the amount of water present. The laws deduced above have been long known by chemists. They are fundamental, and occur in most reactions—that is to say, in all reactions of electrolytes.

If in equation (5) the factor $\alpha\,\delta/\beta\,\gamma$ is a small number, as is probably the case for alcoholates,† the quantity of salt formed is almost zero. So if one mixes alcohol with any base, it only forms a very little alcoholate. But, according to law (23), final equilibrium only depends on relative quantities of the ions present, so if one adds water to an alcoholate it is destroyed, and turns into alcohol and hydrates. Here the *rôles* are changed; water is an acid stronger than alcohol, so it is necessary that water displaces most of the alcohol, as nitric acid displaces water from a hydrate, and this is in full agreement with fact. What is common to every case is the necessity of regarding water as an acid (or, if one likes it better, as a base), which concurs with other acids (or bases) in the equilibriums.

As, according to equation (4), $\frac{dx}{dq}$ is always negative, one perceives that the presence of salt (q) has always an opposing influence on its formation, the same as water behaves. However, the quantity of salt present in the reactions is generally small enough for this influence not to be noticeable.

(*To be continued.*)

* Dr. Arrhenius's mathematical expressions are sometimes unnecessarily long, so I rearrange them whenever convenient without compunction.

† According to all authors, alcohol is a conductor very inferior to water. On the other hand, the conductivity of an alcoholate is comparable to that of a hydrate. (See my work on the conductivity of alcoholic solutions.) [Author's note.]

LEGAL INTELLIGENCE.

Edison and Swan United Electric Company v. Shippey Bros.

This was an action heard before Mr. Justice Kekewich, in the Chancery Division of the High Court of Justice, on Friday last, to restrain the defendants, carrying on business in King-street, Cheapside, from selling a lamp made, as alleged, according to the patent of the plaintiffs (No. 4576 of 1879).

The Attorney-General (Sir R. Webster), Mr. Aston, Q.C., and Mr. Moulton, Q.C., appeared for the plaintiff company; Mr. Arthur Shippey conducted the defendant's case.

Mr. ASTON having opened the case for the plaintiffs,

Dr. Hopkinson, F.R.S., was called and examined, and gave an account of an inspection he had made, in common with Sir Frederick Bramwell and Dr. Fleming, of three lamps which were alleged to have been bought from the defendants. The first of these, he said, contained to all appearance a filament of carbon enclosed within a glass bulb through which the leading wires passed, the carbon filament being attached to the ends of the leading wires. There was an intimation on the glass bulb that the lamp was to be burned at a pressure of 50 volts. He tested the resistance of the lamp in a cold condition by means of a Wheatstone bridge, and found it to be 100 ohms. They afterwards placed the lamp in a photometer and applied an electric pressure of 50 volts to it, measuring the current passing through it and also the candle-power given out from it. The current was found to be ·84 of an ampere and the candle-power 3·61. At the higher temperature the resistance of the lamp was 59·5 ohms. They subsequently broke a small opening in the lamp under mercury, with the result that the mercury passed into the lamp and filled it with the exception of a minute space taken up by a gas bubble, proving that there was exhaustion to a very considerable extent, but that the vacuum was not perfect, although it might be so regarded for all practical purposes. A second lamp was broken up and examined by a microscope. Its diameter was found to be $\frac{1}{1000}$ of an inch, and from the appearance it presented he thought it had been flashed to a certain distance down. From the aspect of the filament, and also from the diminution of the resistance with the increase of temperature, he was almost certain that it was composed of carbon, and that it was, so far as he could make out, a carbon filament, such as that described in Edison's specification. Coming to the third lamp, he said it was to all intents and purposes of the same character as the other two. This is the substance of what was elicited during the first day of the trial.

On Saturday morning Mr. SHIPPEY made an application to be allowed to amend the pleadings, on the ground of the negligence of his solicitors to do so. He wished to amend in regard to the specification of Cheesborough, which was included in the alleged infringement. He argued that that specification was not valid, because Messrs. Sawyer and Man, of America, the inventors, were not parties to the disclaimers in the amended specification filed by J. Y. Johnson, to whom the patent had been assigned.

Mr. ASTON opposed the application, which he characterised as frivolous and untenable.

The learned JUDGE ruled that it would be to defeat justice to allow an amendment which raised an entirely different issue to that which appeared to be set up by the pleadings, and requested both parties to the action to confine themselves to the plain issue whether the defendants had infringed the plaintiffs' patents, which must for the purposes of the action be held good as they stood.

Mr. SHIPPEY then entered upon the cross-examination of Dr. Hopkinson with respect to the comparative extent to which the lamps tested might represent a vacuum, eliciting from the witness that the volume of the bubble left when the mercury entered the globe was as near as he could tell 236 cubic millimetres. The bubble might have been of air, or of some other gas. The vacuum was not very perfect, but was tolerably good for the practical purposes of a lamp. He said that Edison, in his specification, mentioned the millionth part of an atmosphere as an illustration of the degree of vacuum which could be obtained, and the defendants, no doubt, did not succeed in reaching so high a vacuum as Edison had indicated. He was not prepared to say whether Edison made all his lamps with a vacuum of a millionth part of an atmosphere. If the filament contained tetra-chloride of platinum, or was saturated with a metallic substance, he did not think that that would account for the bubble in the globe. If the filament were substantially carbon, that, in his opinion, would be a carbon filament within the meaning of Edison's specification, even though it was coated with platinum. Mr. Shippey asked whether, supposing that the peculiar filament witness tested was coated with a solution of tetra-chloride of platinum, and supposing it was then re-coated with silicon glaze, and it was afterwards re-coated with platinum, the filament being subsequently carbonised, from his experience he would consider that a filament within the terms of Edison's specification. Dr. Hopkinson replied that, supposing all that, of which he detected no evidence whatever, to have been the case, then he would say that it would depend broadly upon the thickness of those coatings whether the filament was broadly and substantially carbon or not. Mr. Shippey asked whether that would not be a semi-metallic substance, to which witness replied that the coating no doubt would be metallic. The body of the filament would be a pure carbon. Mr. Shippey handed a filament manufactured by his firm to witness, asking him if he could tie a knot on it, to which he replied in the affirmative. Mr. Shippey next asked whether that could be done with a lamp-black and tar filament. Witness said it could not, perhaps; but he had no doubt it could if there was a thread in it as described by Edison. Taken generally, the filament was distinctly an Edison filament. At the conclusion of his cross-examination of witness Mr. Shippey stated that the lamps which had been put in, and upon which evidence would be given, were not manufactured in accordance with his specification, although he sold them.

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Charles Henry Gover was next called, and admitted having purchased a number of lamps from the defendants. In cross-examination he admitted also that, when the lamps were supplied to him, Mr. Shippey said that as witness asked for high-resistance lamps they would be supplied, but that the firm did not manufacture high-resistance lamps. The lamps put in by Dr. Hopkinson having been identified as those purchased from the defendants, the Court rose.

On Tuesday Mr. D. H. Bowie and Dr. Fleming were called and examined and cross-examined. Mr. SHIPPEY then said that he felt himself unable, owing to legal technicalities in the case, to properly deal with it. He was willing to submit to a judgment upon terms if the other side would agree. There was an action pending by the Anglo-American Brush Company which he had no doubt would be fought upon the true merits of the incandescent lamp for the first time. It was useless for him to proceed with the case. He would consent to an injunction if execution were ordered to be stayed until the Brush Company's action had been disposed of and every lamp accounted for. He assured the Court that he had amongst his stock four different classes of lamps which did not come within the definition of carbon filament lamps, but as he was labouring under the disadvantage of not being represented by counsel he made this offer to the plaintiffs. He had another action pending for intimidation, with which he would not proceed until the other case which he had referred to was heard.

Mr. ASTON agreed to a stay of execution for a month.

His LORDSHIP said he would simply treat the action as an undefended one. The evidence in favour of the plaintiffs so far was conclusive, and none being adduced by the other side, he had nothing to do but find a verdict for the plaintiffs, who were entitled to either an account or damages, but not both.

Mr. ASTON said that the plaintiffs would elect to take damages.

COMPANIES' MEETINGS & REPORTS.

The Direct United States Cable Company (Limited).

The twentieth ordinary general meeting of this Company was held on Friday, the 29th July, 1887, at Winchester House, 50, Old Broad-street, Mr. John Pender presiding.

The ACTING-SECRETARY (Mr. T. Finnis) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the report is in your hands; I presume you will take it as read. I shall give you, as usual, a few details connected with the past six months' working, with some other general remarks. The revenue for the half-year to 30th June, after deducting cut-payments, amounted to £23,572; and the working and other expenses, including income-tax (but exclusive of cost of repairs) absorb £15,905, leaving a balance of £7,667 as the net profit of the half-year, making, with £229 brought forward from the previous half-year, and £4,246 transferred from the reserve fund account, a total of £12,142, which has been appropriated to the payment of the undermentioned dividends:—Interim dividend of 2s. per share for quarter ended 31st December, £6,071; interim dividend of 2s. per share for quarter ended 31st March, £6,071—total, £12,142. A final dividend of 2s. per share is now proposed for the quarter ended 30th June, the funds for which will be provided out of the interest on the reserve investments. This final dividend, with the three interim dividends already paid, will make up a total of 2 per cent. for our financial year. The revenue at the 6d. rate shows a reduction of £4,873 when compared with the corresponding period of last year, owing to the 1s. 8d. tariff having been in force for the first four months of 1886. This reduction in the receipts would have been much greater but for a large increase in the volume of traffic carried at the 6d. rate. The expenses in London show a reduction in salaries, printing and stationery, and stamps. The increase shown in the rent and office expenses is owing to the removal of the offices, which was notified to the meeting held in January last. The remaining items are about the same in amount as in the corresponding period of last year. The expenditure at the stations shows an increase, on the whole, of £580, owing entirely to the failure of the French Company to perform their engagements. Had these been carried out, a reduction in nearly every item would have resulted. These amounts, however, are all subject to adjustment on settlement with the French Company. On the whole, the total expenses and other payments (repairs excepted), are only £38 in excess of the corresponding period of 1886. The interruptions in the cables during the past half have been three in number—two breaks of the short section and one of the main section having occurred. The repairs were in each case effected with the least possible delay, and at a total cost, including cable, of £5,223, which, as stated in the report, has been charged to the reserve fund, as usual. Up to the present, £4,246 only has been required and applied out of the interest on the investments, towards payment of dividends. The reserve fund account, after providing the above amounts, and being credited with interest on the investments, and profit on sales of securities, now stands at £325,420. The investments, which appear in the balance-sheet at cost price, are worth very much more to-day (about £13,000) than their cost to the Company. Gentlemen, I have given you these hard facts, and now it is my duty to make a few remarks upon the present position of the Company. You are all aware that the 6d. rate still continues. It has been going on for fifteen months now, and I am glad to say that during those fifteen months there has been shown a very wonderful development of traffic. I am not going to tell you that that 6d. rate is eventually to be the permanent rate, because personally I do not believe that 6d. will ever pay even if all our present cables were working to the full extent. But I am quite prepared to say this, that there is a very general opinion not only amongst our shareholders, but amongst the public generally, that the 6d. rate ought to be continued until we are perfectly satisfied of the extent of its development, and how far it would answer our purpose in the future to adopt it before we come to agree upon a rate which would be fair to the shareholders and equally fair to the telegraphing public. I think that that is a policy which is a sound policy, and I hope our shareholders will support us in it. Now, gentlemen, I think it is very right and proper that there should be the most perfect confidence existing between the shareholders and the Directors. We have no secrets. We let you know everything that you are entitled to know, or everything that would be of interest to the Company to know. You see paragraphs in the newspapers every day about negotiations going on here and there as to the settlement of this question. I may tell you that there are no negotiations whatever going on in England. Mr. Mackay arrived in England the other day and, I believe, returned to America. I do not believe that any gentleman officially connected with these companies has had any interview or any exchange of opinion with Mr. Mackay. The settlement of this question, I believe, is to be made on the other side of the Atlantic, and I will give you the reasons for my views. I believe Mr. Mackay, before he left America (about a fortnight or three weeks ago), had an interview with the Western Union Directors. I believe it was arranged then that some committee should be appointed to go into this question. So far we have heard nothing, we know nothing, of what has been done; but we know this, that it is in the hands of men whose interests are very vast indeed. It just occurred to me this morning that I may tell you something of the stake that those gentlemen on the other side hold to show you that their interests are so great that, if they made a good bargain for themselves, they could not make a bad bargain for us, as we must be partners in any bargain or agreement they may come to. Now, gentlemen, I find that the capital of the Western Union—the great land system of America—is about £17,400,000. That is an enormous sum of money. The Baltimore and Ohio Company and the other land line companies' capital is said to amount to £6,000,000. The cables belonging to the American Cable Company, which are leased by the Western Union Company, represent £2,800,000, on which the Western Union have guaranteed 5 per cent. That is a pretty big business of itself. The capital of the Mackay-Bennett Company is something like £1,500,000, making up altogether very nearly £28,000,000 sterling. That is the cost of the system on the other side; therefore, you can well understand that gentlemen with interests so largely in excess of our interests are not likely to make a bad bargain for us. The Western Union during the last two or three half years have paid no dividend. Four years ago they were paying 7 per cent, which went down to 6, down to 5, and so on; and you can well understand that it is to their interest to make a good bargain, and to come to the end of this competition at as early a date as possible. Therefore, I think, gentlemen, that we are right in leaving the whole of the negotiations in their hands. They can come to no decision without consulting us, and we shall come to no decision without being satisfied that your interests are fairly and well protected. With these few remarks, I beg to move—

"That the Report of the Directors, dated 8th July, 1887, together with the statement of accounts to 30th June, 1887, annexed thereto, be and the same are hereby received and adopted; and that a final dividend be now declared of 2s. per share free of income tax, making, with the interim dividends already paid, a total dividend of 2 per cent. for the year ending 30th June, 1887."

Mr. WILLIAM FORD seconded the motion.

Mr. GUESDON animadverted on the general apathy shown by shareholders as to the property in which they locked up their money, maintaining that not one out of fifty knew the conditions under which that property was ruled. It was, therefore, their duty to make themselves acquainted with the Articles of Association and all agreements that the Company might make. He was promised a look at the agreement with the Anglo-American Company, but he had never had time to go to the office. There was another matter he might mention. He did not know whether any imputation might be cast upon him, which he gathered might be the case, in consequence of having received a letter on the subject, in which it was supposed that, owing to the remarks he had made at a meeting, he favoured the Commercial Company. He knew as much about the Commercial Company as the inhabitants of Kamtchatka.

The CHAIRMAN: Who imputed to you anything of the kind?

Mr. GUESDON said that it was no one in the Direct Company. In the report which was made some time ago it was stated that the greatest economy had been exercised in working the Company. In answer to that he would remind them that the expenses of working in London in 1883 amounted to £2,742, whereas in 1887 they were £3,307.

The CHAIRMAN: You are comparing a period when the rate was 2s. with a period when the rate is 6d.; and it so happens that if you double your traffic you must also increase the expense of working it; but, on the whole, as may be gathered from the statement I have made to-day, we have expended only £38 more this half-year than in the corresponding period of last year.

Mr. GUESDON wished to point out that the Chairman had said that all sorts of propositions had been made to avert the difficulties under which they now suffered, but had never ventured to say what those propositions were, and how it was that the present state of affairs was forced upon them.

The CHAIRMAN: You are now stating what is not strictly correct. I have stated the reasons from time to time at meetings, and we had the entire approval of the shareholders for going down to the 6d rate. I stated from time to time that if the Commercial Company had adopted 2s., there never would have been any movement at all, and that we could trust to time to make up what traffic they might take away from us. We were forced in self-defence, and with the entire approval of the shareholders of the Direct Company, to go down to a 6d. rate. Up to that time this Company paid 5 per cent. to their shareholders steadily for years. The

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rate was 2s., and during those years we put by a reserve fund which has made this one of the strongest of the telegraph companies at the present time. I am referring to what you said at the beginning of your speech to-day. You said that shareholders should get hold of the Articles of Association and look into their affairs; but you wound up that by saying, "I have not had time myself to go to the office." You are asking people to do what you have not done yourself; and if you are going to come here and represent the shareholders you should first make yourself thoroughly acquainted with the grievances and the faults that they find with the Board, and then I shall listen to you with the greatest possible pleasure, but when I find you speaking without the book and departing from facts I have a right to protest. I want the shareholders to understand this, that if Mr. Guesdon desires to come here to represent and speak for the shareholders, I ask Mr. Guesdon to come to the office, where we will give him every possible information he can wish to make up a complete and careful statement. He can then make his statement, and you will be able to judge betwixt him and the Board. If he will only do that I shall value Mr. Guesdon's suggestions, but if he goes on to make loose statements, which I and my colleagues must contradict, I think I am entitled to the support of the meeting in protesting.

Mr. GUESDON proceeded to say that when the Chairman got up and spoke of exercising economy, and so forth, he could not reconcile it with the fact that the Directors' fees were £1,500. It was peculiarly disappointing in the circumstances in which the Company was placed to find that the shareholders should receive a dividend of 2s., to be taken out of the reserve fund, and that the Directors should show them no sympathy at all. What was the value of the property, and what was a fair and reasonable compensation for the outlay? That was the important consideration. It did not matter whether an article cost £500. When changes reduced its value to £200 they must be satisfied to deal with it in that sense.

Mr. WEATHERBY had hoped that the hon. proprietor would have concluded his speech by moving an amendment. As that had not been the case he (the speaker) rose for the purpose of doing so. When the question of directors' remuneration was referred to they heard continually that it was necessary to have gentlemen of experience and gentlemen who could protect their interests on the Board. Two per cent. was not an evidence of skill on the part of the Directors. £1,500 every half-year was a very nice income for gentlemen sitting on the other side of the Board. They were told that their present unfortunate state of affairs was in consequence of competition. But there would always be competition in business, and the duty of business men was to endeavour to meet that competition. They ought either to make some arrangement with the Commercial Company, or do something else to meet the difficulty. He quite appreciated the remarks of the previous speaker; and he would conclude by moving, as an amendment, "That the report be not accepted unless the Directors agree that their remuneration shall be struck out of the accounts."

Mr. GUESDON seconded the amendment.

Mr. JOHN NEWTON said he could not sympathise with the amendment just made, though he did sympathise with the feelings of the gentleman who moved it. He considered, however, that the Directors were doing such good, arduous work in the contest that was going on—work which he considered was of vast importance to the welfare of the Company—that the question of the Directors' fees should be in abeyance until they saw what the result of their policy might be. When matters were settled between the competing companies, and they had arrived at a state of peace, if they did not get a very much better dividend, he would strongly urge that the shareholders should take the subject of the Directors' remuneration into their own hands if the Directors themselves did not voluntarily reduce the amount. There was no doubt that this was a burning question, and he had for a long time directed attention to it. He wished, at the same time, to congratulate the chairman on the bold step he continued to take in trenching on the reserve fund to go on paying a dividend. The value of the property as against other Atlantic cables would be greatly strengthened by a continuance of that policy. The principle of some companies in putting away a reserve fund which could not be drawn upon in such a case as theirs was perfectly absurd. If there was one thing that he liked more than another it was to hear shareholders combat directors on a question of accounts, because whatever errors the shareholders might make in so doing it had a tendency to make the Board economise in administration. Nothing could be more satisfactory than the Chairman's statement as to the enormous interests in telegraph cables held on the other side of the Atlantic. He could not help thinking that it was the jealousy of England that had damaged their property.

Mr. JACKSON rose, not so much to find fault as to congratulate the shareholders and the Board on certain circumstances which he would like to mention. Like his friend, Mr. Newton, he could not support the amendment in reference to the reduction of the Directors' fees, because the question was settled at a previous meeting, and he thought it would be highly injudicious to do anything of the kind. He congratulated the meeting on the elimination from the report of what he used to be distressed to hear. He was distressed to hear that the reduction in receipts was attributable to competition. Competition, as had already been explained, was one of the conditions of trade, especially in a country that professed free trade, and to attempt to attribute their losses to such a cause was an absurdity—an anachronism. The tariffs were chosen and enforced by the "pools," and they accepted the conditions and were willing to wait the result. Now, at the present time, after fifteen months' experience of the 6d. rate there was sufficient evidence to satisfy the united Boards on this side that they should put an end to the present state of things. There was the fact that they were paying a very small dividend, a portion of which came out of the interest of the reserve fund. He thought they ought to fix upon a 1s. rate. He took exception to some portion of Mr. Guesdon's remarks. He thought it was very unfair to speak of the extravagance of the management of the Company. There was no comparison as between the Direct and the Anglo-American in that respect. Many of the servants of the Company were living on very low wages, and a cheeseparing policy, with poorly-paid clerks, would be a very false one.

The CHAIRMAN: I have listened to the four speakers with mingled feelings. Two of them have had very considerable experience—I refer to Mr. Jackson and Mr. Newton—who have followed the fortunes of the Company from the beginning. The other gentlemen have not, I believe, had the same experience in telegraph affairs, but I am always prepared to take an idea, let it come from what source it may. But I assure you, gentlemen, if we were to conduct the affairs of the Company according to the four different opinions put before us to-day, we should be in the greatest possible difficulty at the end of a month. Our policy is a consistent policy. We have put it before you from time to time; and if Mr. Jackson, who has spoken so eloquently to-day, will carefully consider the remarks I have made, he will find that what we are endeavouring to do is to arrive at a figure which will yield a fair return to the shareholders, and also be fair and just to the telegraphing public. The telegraph is established, not to benefit the public so much as the people who put their money into it. The public are indebted to the shareholders of the Company, and it is our duty to protect the shareholders as far as we possibly can. I said from the first, and I do not believe now, that the sixpenny tariff will ever pay; but these are all matters that must be discussed calmly, with a view to a peaceable settlement. We are fighting the sixpenny battle now to bring about that settlement. When this question is settled, if it is not done satisfactorily, then I say, in answer to Mr. Jackson and Mr. Newton, then come forward and demand from us an explanation or our resignation. That is my view as Chairman and as a Director of this Company. I need not go into many details, for I think it is unnecessary. I believe the settlement of this question is within a moderate space of time. I have asked you to be patient, because I believe the subject is in the hands of men who will bring it to a satisfactory issue. It is an absolute necessity for the interests of all concerned that its settlement should not be prolonged. You have had confidence in us a very long time. We came into this Company after four years of its existence. Not a shilling had been paid in dividends. We have cleared off £100,000 debentures, which was a burden on the shoulders of the shareholders at the time. We have paid you all through 5 per cent., and at the present moment, we stand with a reserve fund of £325,000. That was not done, Mr. Guesdon, surely, by incompetent men. If there had been the same class of men on the Board when we joined, that would not have been your present position. It was the management of experienced men, and men of ability, and, I am bound to say, of character and reputation that has placed this Company in its present condition. Even the gentlemen who lead the opposition to the Anglo-American Company complimented the Direct Company upon their sympathy with the shareholders. We have done our duty, gentlemen, and are doing it; and I would say to Mr. Newton, if there is any agreement or Articles of Association that you would like to see, come to the office, and we shall lay them before you. They are now in the archives of the Company, and are at your service at any time, but it is not our business to come here and read over the Articles of Association and agreements of the Company. Time is too valuable for that. We have a well-defined policy; we follow that policy, and we believe it to be for the benefit of the shareholders, and I would say, in conclusion, to the body of shareholders, "Leave well alone."

Mr. WEATHERBY felt that there was a want of courtesy in the remark made by the Chairman as to his (the speaker's) want of experience in this kind of business. He had unfortunately too much experience in it, being a shareholder in the Anglo-American and the Direct as well. He still maintained the justice of his remarks, although he would withdraw his amendment, because he was quite sure it would not be carried. Would the Chairman kindly give his own opinion as to what he considered a fair time to wait for a settlement?

The CHAIRMAN replied that the position he occupied in relation to other companies would not warrant his making any remarks that would tie their hands in any way whatever. While he had made the remark about Mr. Weatherby's inexperience in regard to telegraphy, he had not the slightest desire to reflect upon that gentleman's general experience and knowledge.

The motion was then put and carried.

Mr. UNDERDOWN, Q.C., moved—"That Mr. John Pender be and he is hereby re-elected a Director of this Company," and said that he was quite sure that if Mr. Guesdon would go in for reducing the number of Directors that gentleman would not like to see it diminished to the exclusion of their excellent Chairman. He was glad to see that Mr. Pender occupied such a prominent position at the dinner to commemorate the fiftieth anniversary of the electric telegraph, where the highest electrical authority, Sir William Thomson, said that it was to Mr. Pender and Mr. Cyrus Field that was due the honour of commencing Atlantic telegraphy.

Mr. FORD seconded the motion, which was cordially agreed to.

The CHAIRMAN next moved—"That Mr. Emanuel Maguire Underdown be and he is hereby re-elected a Director of this Company," and referred to the excellent service that gentleman had rendered to the Company through his great legal knowledge, and more particularly in dealing with the French Company, because of his perfect command of the French language.

The Lord HAWKE seconded the motion, and it was carried unanimously.

Mr. JACKSON next proposed the re-appointment of the Company's auditors (Messrs. J. G. Griffiths and J. Sawyer) for the ensuing year at a remuneration of £50 each, eulogising the painstaking manner in which those gentlemen performed their duties.

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Mr. NEWTON seconded the motion, and it was carried *nem. con.*

Mr. SHELDON proposed, and Mr. NEWTON seconded, a vote of thanks to the Chairman and Directors, which was cordially passed.

The CHAIRMAN: Gentlemen, I must in the first place thank you for the honour you have done me in re-electing me a Director, and in the second place to thank you on behalf of my colleagues for the compliment you have paid us by this vote of your renewed confidence. There is an old saying among the Italians that it is always pleasant to go away with a sweet taste in one's mouth, and I want you to carry that sweet taste away to this extent—that you may rest assured that the Directors have a great sympathy with the shareholders at the present time. The dividend we have paid you to-day is, I must confess, a miserable one, but we are only partners, and small partners, in a large concern, and consequently we are obliged to be guided more or less by our more powerful allies; but I think I have stated clearly to you to-day that it is to the interest of those allies to settle this question as soon as possible, when we shall be in a position to declare a higher dividend.

The proceedings then terminated.

The Edison and Swan United Electric Light Company (Limited).

Report of the Directors, to be presented to the shareholders at the fourth annual meeting to be held at the Cannon-street Hotel, on Tuesday, 9th August, at 12 o'clock.

The sale of lamps and the business of the Company has progressed in a satisfactory manner during the year, and has resulted in a profit of £16,221. 17s. 8d., which sum the Directors will propose to apply to the extinction of the amount standing to the debit of profit and loss. During the year the Directors have paid off the mortgage of £3,000 on the Benwell, and a like amount on the Green-street property. They are trying to find purchasers for these freeholds. Installation work has been more active during the past twelve months, and the Company has lighted, amongst other places, the Athenæum and National Liberal Clubs, the National Provincial Bank, the house of H.R.H. the Duc d'Aumale, various ships, and private houses in town and in the country. The Directors in their last report informed the shareholders that Messrs. Woodhouse and Rawson had given notice of appeal against the judgment of Mr. Justice Butt in both the actions for infringement of the Company's patents which he had decided against them. The appeal in the first action was heard before Lord Justices Cotton, Bowen and Fry, who upheld the judgment of the Court below. The appeal in the second action was heard before Lord Justices Cotton, Lindley, and Lopes, who also upheld the judgment of Mr. Justice Butt. Messrs. Woodhouse and Rawson were condemned in costs in both actions, in respect of which costs they have as yet made no payment. Other actions are pending in connection with the Company's patents, but in these the Directors are advised that there is no probability of the judgments of the Courts of Appeal being reversed. The shareholders may rest assured that the Directors will do all in their power to maintain the valuable patent rights which the Company possesses. The electric lighting industry, in spite of the difficulties created by the Electric Lighting Act, is progressing, although the rate of progress in the United Kingdom is slow compared with that in the United States and in some parts of the Continent, and the business generally is becoming sounder than it was, although much cheap bad installation work is still being done. The Directors are preparing to meet any increased demand which may arise for lamps in the coming winter. Mr. Shelford Bidwell, F.R.S., retires from the Board, and offers himself for re-election as Director. Messrs. Quilter, Welton and Co., the auditors, also retire, and offer themselves for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 15th, 22nd, and 29th July amounted to £2,870, £2,763, and £2,500 respectively.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of July was 3,277, estimated to produce £2,600, against 3,412 messages, producing £2,818 in the corresponding month of last year. The traffic receipts for the month of April, estimated to produce £2,900, realised £2,964.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of July amounted to £1,532, against £1,280 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July amounted to £45,805, and to £43,708 in the corresponding period of 1886.

EASTERN EXTENSION AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July amounted to £38,520, and to £34,931 in the corresponding period of 1886. Increase £3 589.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending 30th July amounted to £4,6:0.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the three weeks ending July 15, 22, and 29, were £2,267, £1,771, and £2,092 respectively, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 31st July are £2,431, as compared with £2,414 in the corresponding period of 1886. The April receipts, estimated at £5,566, realised £5,400.

WOODHOUSE & RAWSON (LIMITED).—The application list of this new company's shares will be closed on Monday next for London, and on Tuesday, at 12 o'clock, for the country. We hear that the shares are already over applied for, and business has been done at ½ to ¾ premium.

NEW COMPANIES REGISTERED.

UNITED TELEPHONE COMPANY OF ROSARIO (LIMITED).—Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, with a capital of £20,000 in shares of £10 each. Object: To purchase and take over the undertaking known as "Compania Telefanos Unidos del Rosario" (now established in Rosario in the Argentine Republic), upon the terms of a draft agreement already prepared and made between the River Plate Trust, Loan, and Agency Company (Limited), of the one part, and the United Telephone Company of Rosario (Limited) of the other part, subject to any modification the directors may approve, to carry on the businesses of telephone and telegraph companies in the Argentine Republic. The first directors shall be appointed by the subscribers to the Memorandum of Association; qualification, the holding of at least £200 in the capital of the company; remuneration to be fixed in general meeting.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG 3.		BUSINESS DONE WEEK ENDING AUG. 3. Highest.		Lowest.	
Anglo-American	36½,	37½ xd	—		—	
Do. Preferred	59½,	60½	60½		59½ xd	
Do. Deferred	14½,	15½	—		—	
Brazilian Submarine	11½,	11½	11 7-16		11 3-16	
Cuba	12,	12½	12½		xd	
Do. Preference	18,	19	—		xd	
Direct Spanish	2¾,	3	—		—	
Do. Preference	7½,	8½	8½		—	
Direct United States Cable	9,	9½	9		8¾	
Eastern Telegraph	11,	11½	11½		10 15-16 xd	
Do. 6 per Cent. Preference	14,	14½	14½		14 1-16 xd	
Do. 5 per Cent. Debentures, 1899	105,	108	—		xd	
Eastern Extension	11¾,	11⅞	11⅞		11⅞	
German Union	10½,	11	10 13-16		—	
Globe Telegraph and Trust	5½,	5⅝	5 9-16		5⅛	
Do. Preference	13,	13½	13½		13	
Great Northern	13½,	14	13¾		13¾	
Indo-European	85,	87	—		—	
Reuter's	7½,	7¾	—		—	
Submarine	175,	185	—		xd	
West India and Panama	⅝,	¾	⅝		—	
Do. 1st Preference	8¾,	9½	9½		9	
Western Brazilian	8,	8½	8		—	
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	104,	107	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	—		—
Oriental	½,	¾	—		—
United Telephone	11¼,	12¼	12 1-16		12

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—		—
Do. (fully paid)	3,	4	—		—
Swan	1½,	1¾	1¾		—
Maxim Weston	⅛,	¼	—		—

MISCELLANEOUS.

Telegraph Construction	35,	36	36		35½
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	22¾		—

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NOTES.

KARLSBAD.—A concession has been obtained for the construction of an electric tramway in this town.

PARIS THEATRE LIGHTING.—The electric light is now being installed in the Théatre de la Rennaissance, the Théatre de l'Ambigu, and the Théatre des Menus-Plaisirs.

THE AMERICAN NATIONAL TELEPHONE ASSOCIATION.—The American National Telephone Association has decided to hold its meeting at Pittsburgh, commencing September 26th.

GENOA.—The Ganz Company of Buda-Pesth is negotiating for the establishment of a central lighting station on a very large scale at Genoa. Zipernowski-Déri transformers will be used.

ST. PETERSBURG.—An exhibition of the mineral oil industry and other lighting materials will be opened at St. Petersburg in November next. There will be a section for electric lighting.

LARDEN'S "ELECTRICITY."—We have received from Longmans, Green and Co. a copy of "Electricity for Public Schools and Colleges," by W. Larden, M.A., author of "A School Course in Heat."

ELECTRIC RAILWAYS FOR INDIA.—Our contemporary, the *Indian Engineer*, referring to the progress of electric railways, remarks that in India there is "not only a large but a very promising field" for this application of electricity.

PARIS.—One of the iron conduits employed in conveying compressed air for supplying motive power to some dynamos in the Faubourg du Temple burst open on Monday last and caused very considerable damage, besides wounding three people.

MALTON.—The Malton Local Board has received an "informal" offer from an electric lighting company to undertake the lighting of the district for £1,500 per annum. The present cost of gas lighting is £580, so that this is, no doubt, a genuine offer.

LUCCA.—A small installation of Zipernowski-Déri transformers has been put up at Lucca, and is used both for public and private lighting, although there are only 200 lamps in all. Power is obtained from the River Lima at a distance of three miles from the town.

THE ATLANTIC CABLE RATES.—A New York telegram in the *Standard* states that the Commercial Cable Company has announced that it will in a fortnight reduce its rate to 12 cents per word, unless meanwhile other companies agree to advance the charge to 40 cents.

POST OFFICE TELEGRAPH CLERKS.—From the annual report of the Civil Service Commissioners we learn that during the last twelve months there have been 1,177 male competitors for 220 vacancies on the telegraph staff, and 836 female competitors for 80 vacancies.

LIGHTHOUSE COMMUNICATION BY TELEGRAPH.—According to the *Daily Telegraph*, Sir E. Watkin has agreed to take charge of a Bill in the House of Commons during the present Session to enable Lloyd's to connect (at their own expense) the lighthouse on Tory Island with the mainland of Ireland by sudmarine cables and land wires, and to establish telegraph stations.

EARLY USE OF THE MAGNET IN SURGERY.—In the *Phil. Mag.* for August, 1808, there is an interesting account of a successful operation performed by the aid of a magnet, in which a small piece of iron, which had *embedded* itself in the eye of a blacksmith, was extracted after resisting the efforts of the surgeons for no less than five months. So far as we are aware, this is the earliest record of the use of the magnet in surgery.

TELEGRAPH LINES IN THE EAST.—The Netherlands Indian Government will, it is said, make provision for stretching a telegraph line across Sumatra from west to east to continue the existing lines to Deli. There is some talk also of laying a cable from Situboudo, in Java, to Macassar, in Celebes, *viâ* Bali Buleling. Borneo and other principal islands in the Netherlands Indian Colonies are at present cut off from all telegraphic communication.

NIAGARA.—It is stated that the Buffalo Electric Light Company has entered into a contract with the Niagara Falls Hydraulic Tunnel and Power Company to take 10,000 horse-power, at 15 dollars per horse-power per annum, for lighting the city and manufacturing purposes. The route for the proposed cable has been surveyed from Niagara Falls, a distance of 20 miles. Negotiations are also pending for lighting and supplying power to other towns in the vicinity.

BERLIN.—The following are the latest statistics showing the position of the telephone service in Berlin :—Number of subscribers, 6,000 ; length of wire, 12,000 kilometres ; conversations per diem, 100,000 ; inter-urban communications, 1,500 to 2,000 per day. From these figures it appears that in proportion to population the telephone is nearly five times as much in use in Berlin as in London ; the number of communications per instrument per day is also very high.

OMNIBUS LIGHTING.—The General Omnibus Company are following the example of their competitors, the Road Car Company, in making trials of electric light in their vehicles. The Omnibus Company has, however, adopted an accumulator service. This will, we fear, prove a severe blow for the Eclipse Primary Battery people, who, judging from their financial proceedings, must have anticipated that nothing but the Eclipse Battery would ever be used for the purpose in all the omnibuses and tramcars of the kingdom.

ELECTRIC LIGHTING IN SCANDINAVIA.—Electric lighting was recently introduced at the Central Railway Station, Christiana, very successfully, involving a loss to the gas works of £2,000 a year. In Christiana the gasworks are city property, and the Corporation is now going in for an electric light plant of its own. The steamers running along the West Coast of Norway have been fitted up with Edison installations. In Stockholm the leading theatre is now lighted by electricity, and the city of Gothenberg, Sweden, is to have its streets lit by electricity.

CHICAGO.—At Chicago an extensive scheme for lighting the whole of the bridges and viaducts of the river has been adopted, and will at once be carried out. One hundred arc lights will be required, and the circuit will be ten miles in length. The specification states that the cables, after being led to the river-side by an underground channel, are to be dropped into the river, and suspended below the frost line in such a way as to be readily removed, when required, for dredging or other purposes. The cables are to be iron armoured, and the insulation is to be not less than 500 megohms—per mile presumably.

ELECTRIC TRACTION AT PHILADELPHIA.—Mr. Reckenzaun (upon whom, by the way, our American cousins have bestowed the distinguished title of "Professor") has recently been assisting at some trial runs of an electric tramcar in Philadelphia. Storage cells are used to supply current to a Sprague motor,

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and very successful results have been attained. It is unnecessary to add that Mr. Reckenzaun's long continued study and extensive practical experience in all matters appertaining to electric traction and the working of secondary batteries should render his services of the greatest value to the American electricians, who are only just commencing to launch out in this particular direction.

BRAZIL.—The Zipernowski-Déri transformers have made their way into Brazil, and an installation of 1,000 lamps is in process of construction at San-Paulo. The Ganz Company has supplied the engines, of 150 horse-power, and also the arc lamps. Edison lamps of 16 candle-power have been supplied by the Compagnie Continentale of Paris. Overhead conductors of bare copper are used. The installation has been carried out by the firm of Marques, Montte and Co., who have acquired the exclusive rights for the Zipernowski-Déri system in Brazil. A paper published in Rio de Janeiro states that a new incandescent lamp, invented in Brazil, has recently been exhibited in that city, and, in the opinion of the local experts, is superior to either Edison or Swan.

THE CARDEW VOLTMETER.—Messrs. Paterson and Cooper write us as follows:—"In describing the above in your issue of last week there occurs an error which we should like to correct. The instrument is said to read to 360 volts, a mistake doubtless arising from the fact that the one inspected by you had not been calibrated. When the calibration is completed there is marked on the dial, in addition to the scale of 360° in black, a direct scale of volts in red, one end of the pointer painted black showing the deflection in degrees, the other painted red giving the volts producing it. The instrument described is calibrated to 120 volts, the deflection produced by this difference of potential being 360°. We are at fault in not pointing this out when we sent you the voltmeter."

BEANFEAST TO THE EMPLOYÉS OF THE ELECTRICAL POWER STORAGE COMPANY.—The annual dinner to the *employés* of this company took place in the Banqueting Hall, at the Royal Pavilion, Brighton, on the 30th July. The dinner was served at 12:30, the chair being taken by Mr. J. Irving Courtney, managing director, and the vice-chair by Mr. E. Clark, foreman of the works, in the unavoidable absence of Mr. W. H. Patchell, works manager. The chairman proposed the loyal toasts, the vice-chairman "The Company and Directors." After these toasts had been duly honoured, the chairman referred to the extensive application at home and abroad of the E. P. S. accumulators, and especially to the rapid increase in the demand for storage batteries in America. After several songs and speeches, the company dispersed for the beach, and met again at the railway station at 8:40 for the return journey to London. This makes the fifth annual dinner.

MORE ACCIDENTS FROM GAS IN THEATRES.—Some of our Continental contemporaries make it a practice week by week to record all the cases of fires or explosions due to coal gas which come under their notice, and it is but seldom that their columns are devoid of such catastrophes. We have not hitherto thought it desirable to follow this practice; but in view of the recent disclosures in the *Saturday Review* as to the condition of the London theatres, it is certainly the duty of every one concerned to endeavour to bring home to the authorities the very real character of the danger which exists in every public building of this character lit by gas light. At Toulouse a concert hall has just been almost entirely destroyed by fire. The outbreak occurred at two o'clock in the morning, and was due to the escape of gas. At the theatre at Nîmes, on Monday last, during a distribution of prizes to the pupils of the conservatoire, an explosion of gas took place in the basement, seriously wounding an attendant, and causing a panic which might have had the gravest consequences.

THE BRITISH ASSOCIATION.—A meeting of the Newcastle-on-Tyne Literary and Philosophical Society was held on Wednesday to consider the advisability of inviting the British Association to Newcastle in 1889. The Mayor of Newcastle (Sir B. C. Browne) occupied the chair, and among those present were representatives of the different educational and scientific institutions and the Mayor of Gateshead and Tynemouth. Lord Armstrong wrote approving the project for which the meeting had been called, and offering a contribution of £200 towards the expenses. Sir Lowthian Bell and others also wrote in favour of inviting the British Association. Dr. Hodgkin moved that the Mayor be requested to invite the British Association to Newcastle in 1889, which was seconded by Dr. Brady, of Sunderland, and supported by the Sheriff of Newcastle and carried. The following were appointed a committee in connection with the proposal:—Lord Armstrong, Lord Ravensworth, Sir Charles Mark Palmer, M.P., Sir Lowthian Bell, the Mayor of Newcastle (Sir Benjamin Browne), Mr. Hodgkin, Prof. Merivale, Mr. W. D. Stephens, Mr. N. H. Martin, Mr. Dunn, Mr. Emley and Mr. J. J. Butcher.

THE FIRE AT WHITELEY'S.—We notice that Mr. Whiteley is reported to have remarked to an interviewer that he had already adopted every possible precaution against an outbreak of fire which the ingenuity of his architect could suggest. We may, however, be permitted to observe that one precaution had been omitted. Mr. Whiteley's premises have hitherto been only partially lighted by electricity, and the descriptions of the recent fire were unanimous in attributing the rapid extension of the flames to the ignition of gas from the broken pipes. On this question the *Daily News* writes as follows:—"The fire at Whiteley's gives to electricity an opportunity of turning the tables upon gas. When first electric lighting came into vogue, there were many alarms as to the risks of fire through overheating of the wires. These had to be allayed by soothing assurances as to the character of the currents, by careful insulation arrangements, and by the invention of fusible plugs to break the current in case of the slightest danger. In Saturday's fire gas seems to have played an important part. A correspondent writes to us to point out that the vast system of gas-pipes in the burning premises aggravated the difficulties of the firemen, and probably prevented the restriction of the fire to its original limits. 'If,' he adds, 'the entire buildings had been lighted by electricity, much of the danger might have been averted.'"

FAILURE OF THE AMERICAN CARBON COMBINATION.—The attempt to maintain "a ring" amongst the American carbon makers has utterly broken down. Previous to the combination the selling price of carbons had been forced down to $10 or $12 per thousand. The prices fixed by the "ring" were from $20 to $25 per thousand, with the immediate effect, as our readers have already been informed, that several of the principal electric light companies commenced to promote a "Mutual Carbon Manufacturing Company," with the intention of supplying their own wants. The carbons are chiefly made from the coke of petroleum and naphtha, and it was proposed by the syndicate to take the entire petroleum-coke product of the Standard Oil Company, who are the largest producers of the coke in the States. Whether this scheme will be carried out now that the Cleveland "ring" has collapsed remains to be seen. One company, at any rate—the Thomson-Houston—

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has started carbon making on its own account. Prices have again fallen to the old figures, and as it appears to be admitted that these rates cannot possibly be remunerative to the makers, it is to be regretted that the combination sacrificed their interests in a foolish attempt to obtain a purely fancy price, the result of which might have been foreseen. It seems, moreover, to have been understood that the users would not have objected to a moderate advance of $2 or $3 per thousand.

FINANCIAL CONDITION OF THE ELECTRIC LIGHTING COMPANIES.—The following paragraph has appeared in the daily press. The facts are gleaned from *Burdett's Official Intelligence*, published under the sanction of the committee of the Stock Exchange:—"Anglo-American Brush Electric Light, with a capital of £800,000 in £10 shares, in February, 1884, by the depreciation in the assets of the Company £5 per share was written off, reducing the capital to £400,000; the £5 on which £3 is paid present price £1. 10s. to £2; £5 fully-paid £3 to £4, dividend 12th February, 1886, 2 per cent., nothing since on half the original capital. Maxim-Weston Electric Company, established in 1881 as the Electric Light and Power Generator, authorised capital is now £125,000 divided into 500,000 shares of 5s. each. The nominal value of each share was reduced by resolution in May, 1884, from £1 to 10s., and again in February, 1886, from 10s. to 5s. Present price of shares 2s. 6d. to 5s., dividend paid in February, 1886, on reduced capital 7½ per cent., February, 1887, 5 per cent. Electric Sun Lamp and Power Company in liquidation; Swan United Electric Light Company; Swan and Edison. The Edison Company made over to the new Company all their asssets for £125,000. Mr. Edison is entitled to a deferred interest. The amount of interest due on these shares 30th June, 1886, was £71,887. Profit on year's working, 1885-6, £24. No dividend has yet been paid. There is a mortgage of £20,000 on Company's freehold property. Shares £3½ paid present price £1¼ to £1½."

NAVAL AND MILITARY DEFENCE.—Under the signature of "Admiral," the following letter has appeared in one of our daily contemporaries:—"In your report upon the Naval Review you declared electricity to be of greater power than armies and navies. The want of this power has been clearly proved in to-day's papers, which ask, 'Why did not the coast-guard at Dungeness telegraph to Captain Long at Deal, that the enemy's fleet was passing?' Why? Because the Admiralty has no telegraphic system. The Admiralty should be in direct telegraph communication with all coastguard stations, which in war time would act as sentinels round our extensive coast and double the protecting power of our fleets. The same may be said of the army. There is no telegraph communication to all the barracks and isolated forts throughout the kingdom. The artillery are not exercised in embarking their guns on the railway, so, if they had been wanted at Falmouth, they would probably (through loss of time) have arrived there to find the enemy well established. A few telegraph wires and the necessary knowledge for the officers and sergeants to work the telegraph machines, would render our army and navy ten times more effective. Take as an instance, Horfield Artillery Barracks, three miles from Bristol; telegraph wires pass about a dozen yards from barrack wall; nearest telegraph station about half a mile distant, closed at night. Comment is unnecessary, perhaps useless. Nothing will be done till the enemy is hammering at our doors, and then it will be too late, as Fremantle has proved that even London is not safe."

THE AMERICAN INSTITUTE ELECTRICAL EXHIBITION.—Blank application forms for space to display electrical appliances at the American Institute Electrical Exhibition, to be held in New York City, September 28th to December 3rd next, are now being sent out by the secretary, Joseph P. Wetzler. The office of the secretary is at room 175, Potter-building. The classification of the electrical exhibition shows six sections as follows:—*Section I.*—"Production of Electricity."—1. Dynamo and magneto-electric machines. 2. Primary batteries. 3. Thermo-electro apparatus. 4. Static electric apparatus.—*Section II.*—"Apparatus Requiring Powerful Currents."—1. Electric motors and transmission of power. 2. Electric railways. 3. Storage batteries. 4. Electric illumination. 5. Electro-metallurgy and electro-chemistry. 6. Miscellaneous application of powerful currents.—*Section III.*—"Apparatus Requiring Comparatively Weak Currents.—1. Fire and burglar alarms, annunciators, watchmen's time detectors, electric bells, &c. 2. Electric telegraphs, telephones, microphones, photophones and radiophones, and other apparatus for electrical communication. 3. Electric registering and signalling apparatus. 4. Application of electricity to the mechanic arts. 5. Applications of electricity to heating and ventilation. 6. Electric clocks and time telegraphs. 7. Electric medical apparatus of all descriptions. 8. Application of electricity to writing and printing. 9. Electrical toys. 10. Miscellaneous applications of small currents. *Section IV.*—"Electric Conductors."—1. Electric light and power conductors. 2. Telegraph and telephone wires and cables. 3. Insulating materials, electrical joints and connections. 4. Electric underground wire systems. *Section V.*—"Electrical Measuring Apparatus."—1. Voltmeters and ammeters. 2. Galvanometers, rheostats, &c. 3. Condensers, switches, keys, &c. *Section VI.*—1, Historical and miscellaneous exhibits. 2. Educational and bibliographical.

THE TELEPHONE IN CHINA.—The *Central News* is enabled to give an outline of the negotiations which have led up to the recently reported concessions by the Chinese Government to an American syndicate. During the past winter Mr. Wharton Barker, a Philadelphia capitalist, succeeded in interesting individual members of the Chinese Legation at Washington in the advantages to be derived from the extended use of the telephone in China. A number of exhibition tests were made between New York and Washington for the purpose of demonstrating to the Chinese the facility of long-distance communications by means of the telephone under certain conditions. The members of the Legation and other prominent Chinamen then in America conversed with ease between these two points, and were deeply impressed with the remarkable results obtained. The outcome of these tests was the formation of a syndicate for the purpose of proving in China what has already been demonstrated in America. An expedition was arranged with Count Mitkiewitz as the diplomatic head—he also representing the capital—and Mr. Barberie as chief electrician. Early in March material and telegraphic engineers were despatched in a vessel *via* the Suez Canal. Later Count Mitkiewitz and Mr. Barberie went to China *via* San Francisco. A telegraph line, having its headquarters at Pekin, was constructed, and the New York and Washington telephone experiment repeated to the satisfaction of the Chinese authorities. The Morse system of telegraphy was also successfully illustrated, and the concession to Mr. Barker and his friends followed. The railway and banking concessions have, however, not yet been made, and are merely put forward as possibilities. The American silver people may enter the telephone enterprise in the hope of ultimately getting banking concessions, and railway contractors may associate themselves with, and Barker with a similar hope. It can be stated, how with the

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nothing further than telephone or telegraph concessions have been granted, and that Mr. J. Gould has no interest in the matter.

PRIMARY BATTERY SPECULATIONS.—How much longer, we wonder, is electricity to be made the happy hunting ground of needy speculators and adventurers? We do not hesitate to say that the numerous attempts which have been made within the last twelve months to float primary battery companies, not one of which is at the present time doing a legitimate trade, constitute a most discreditable chapter in the history of electrical finance. An attempt is now being made to get the public to subscribe £100,000 for the patent rights of a nitrate of soda battery. We are content to receive Prof. S. P. Thompson's bare word for the fact that the battery may be taken to be a decent specimen of its class. It is, however, necessary to observe that in the learned professor's remarks, which are made to figure so prominently in the prospectus of the company, he confined himself almost entirely to an emphatic assertion of the value of electric safety-lamps in mines—a point upon which nearly every one is agreed, but which has nothing to do with the technical or commercial merit of the battery in question; indeed, as for the technical features of the cell, no information has yet been made public. "The battery is acknowledged by the press," so the advertisements inform us, "to be the simplest and most effective electric battery that has yet been invented." The daily press is, of course, fully recognised as the supreme authority upon the point in question; as for ourselves (and we may include our technical contemporaries in the statement), it would appear that the promoters prefer not to run the risk of submitting the cell to an independent opinion. We should like to know to what extent (if any) the shares of this company have been taken up by anyone who is capable of forming an independent opinion upon the relative, not to say the absolute, value of the patents. In the present state of electro-chemical science we have no hesitation in saying that it is impossible to devise a primary cell which shall have a commercial value anywhere approaching £100,000. So long as zinc is burned as fuel with a resulting E.M.F. of a couple of volts (approximately) it is impossible to admit that any form of battery—whatever else its merits may be—can possess such an enormous superiority over everything hitherto invented as would justify an estimate of its value amounting to £100,000, or a half, or a quarter, or perhaps a tenth of that sum.

OVERHEAD LINES FOR ELECTRIC TRAMWAYS—ACCIDENT IN AMERICA.—At Montgomery, Alabama, eleven miles of street railway lines are worked by electric motors, the current being taken off from an overhead copper line. One of the disadvantages of that system—which it may be well to state has never been adopted in this country—is that the overhead wire cannot be covered with any insulating material, consequently if the wire does give way the results may possibly be serious. This possibility has just been exemplified at the expense of Governor Seay. The incident is thus reported in a local journal:—"Governor Seay was the victim of a peculiar accident this afternoon. He and his private secretary, J. K. Jackson, were driving down the main thoroughfare of the city when one of the guy wires which supported the overhead cable of the electric street railway broke and fell to the ground, striking the Governor's horse. The wire was heavily charged with electricity, and the horse, becoming entangled, was shocked and burned to death in a few minutes. A second later the wire would have struck the Governor and Mr. Jackson instead of the horse." If this unfortunate mishap had occurred been our own country, the sermons which would have been at two o'clock by the daily press can easily be imagined. In America they take these things very quietly. The *Philadelphia Press*, for instance, after making a single characteristic observation, passes on without further ado to congratulate the citizens on their rapid progress in the arts of civilisation. The following is the reflection which suggests itself to the Philadelphian mind:—"The announcement that Governor Seay, of Alabama, came near meeting his death through the fall of an overhead cable of the Electric Street Railway in Montgomery is an indication of the rapidity with which electricity is being adopted as a means for propelling cars in streets." We may as well quote the conclusion of the article, which reads the lesson that we have recently been endeavouring to enforce in this country:—"The substitution of some more efficient means for propelling street cars than the slow, costly, and cruel method now most in vogue seems certain to come soon. Humanity, if nothing else, ought to bring this about. The sufferings of street-car horses in the heat of summer and during the storms of winter ought to touch the hardest heart, but unfortunately trade does not take into account the sufferings of dumb beasts provided the balance is on the right side of the ledger. It is only by showing that there will be a larger balance on that side that a substitution of mechanical force for horse flesh will be made. Let us hope that that time is near, and that by the progress in invention the sympathies of the humane will no longer be excited by the tugging and straining under the goad of so useful and intelligent an animal as the horse."

SOPRANO *v.* BASSO FOR THE TELEPHONE SERVICE.—From the most elementary theory of the telephonic transmission of sound we learn that upon a line of given resistance, and given permittance (or capacity) and inductance, the distortion of the current waves increases with the rapidity of vibration, or the pitch of the sound; while, on the other hand, the amplitude of the current wave, on which depends the volume of sound heard in the receiver, varies inversely with the pitch. From these considerations, it might be argued that the male voice should prove decidedly better than the female for telephonic purposes. In practice, we know that this is not the case, for although certain male voices do render themselves remarkably well, yet the general average is, if anything, in favour of the female voice. Even if this latter opinion be disputed, it will, at any rate, be admitted that there is no such marked superiority on the masculine side as the theoretical considerations would lead us to expect. The explanation of this discrepancy has received considerable assistance from recent developments of acoustic theory at the hands of Herr Grassman, and by the experiments of Herr Lahr; the result is the more interesting because the explanation is arrived at, not by any impeachment of accepted electrical laws, but, as we have just indicated, by an addition to our knowledge of acoustics. It is already well known that the *timbre* ("clang-tint," as Tyndall proposed to call it), which we recognise in the same tone when sounded upon different musical instruments, or by different human voices, is due to the presence, or the greater relative prominence, of the different harmonic overtones by which the fundamental is accompanied. In the same way it has long been known that the various vowel sounds, even when pronounced by the same voice in the same tone, are each accompanied by a distinct and characteristic set of overtones. It has also more recently been shown by Lahr that the overtones for one and the same vowel are subject to variation both in pitch and in intensity, according to the inflection with which it may be uttered, and they change also with the register of the voice. So far we have perhaps learnt little which our previous knowledge might not have enabled

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PHOTOMETRY.—MR. DIBDIN ON THE PENTANE STANDARD.—The report on Photometry, presented by Mr. W. J. Dibdin to the Metropolitan Board of Works, constitutes one of the most important papers on the subject which has hitherto appeared; it comprises an elaborate series of tables containing the results of over 20,000 recorded observations. The whole of the report is of interest, but we are unable to do more than reproduce the most important portion, which is as follows:—"In selecting a substitute for the present legal candle, care should be exercised to ensure that it complies with the three main conditions which apply to the present standard, viz.: 1. That it should have a definite combustible material; 2. That the condition in which that combustible material exists at the time of use should be under control and capable of inspection for verification. 3. That the rate of combustion, and the manner in which it is effected, should be readily and accurately observed. By applying these considerations to each of the proposed standards, a guide is at once obtained for the selection of the most suitable. The pentane air gas, as devised by Mr. A. Vernon Harcourt, the Keates lamp, and the amyl-acetate flame of Herr von Hefner-Alteneck, all answer to the requirements of these conditions; while the Methven screen, the pentane lamp, the ten candle test, and its improved form, which I have called the 'Pentane Argand,' although each giving most excellent results in practice, fail to comply with these requirements, as they each depend upon a purely arbitrary rate of consumption of combustible material, coupled with a definite height of flame, but no check is afforded by means of which an involuntary error in the setting of the flame by the observer can be afterwards detected. Of those proposals answering to the above conditions, the Keates sperm oil lamp has one serious defect—in that the wick, when once used, cannot be re-ignited without fresh adjustment or renewing, and thus a discrepancy is apt to occur. Furthermore, the practical difficulty found by various operators in obtaining a flame of uniform character seems to have been more serious than I had hitherto been led to suspect; and to such an extent has this been experienced that I am compelled to put it on one side in face of the more easily managed pentane air gas and other proposed substitutes for candles. The amyl-acetate lamp has many points which entitle it to very careful consideration, not the least among these being its extreme simplicity and portability. It is, in fact, only a carefully constructed spirit-lamp; and in actual work has given most admirable results. Unfortunately, however, the colour of the flame is its one weak point; and for this reason I am of opinion that it is not the most suitable for adoption as the standard. On the other hand, I have found the pentane air gas to comply with every demand made upon it, and to answer to the full all the claims made for it by the inventor. The facts brought out by this inquiry have shown that the method of preparing the air gas is at once easy and safe; that the measurement of the volume of gas used is simple and reliable; that the adjustment of the height of the flame is a matter of certainty; its steadiness all that can be desired, when due care is taken and proper apparatus employed; and that the colour of the light afforded is precisely the same as that of the standard comparison gas-flame. With reference to the steadiness of the flame, I can fully bear out all I formerly said of it. During the exhaustive trials to which it has been subjected, not a single test has been lost or doubted from this cause. The only necessary precaution was to avoid irregular air currents; the photometer chamber in which it was burning being so arranged as to provide a large volume of air moving at a low speed. This was done by closing the top of the chamber—which was 2ft. 8in. high, by 18in. by 21in.—by means of a board perforated with a circular aperture 4 inches in diameter. The bottom of the chamber was left open at the back and front about 6 inches from the table on which it stood. It was found that such an arrangement was also advantageous in the case of the pentane and amyl-acetate lamps. Should it be desired to use the flame in an unsuitable position as regards draught, the use of the chimney (as arranged by the inventor) entirely obviates all difficulty from unsteadiness, and renders the flame absolutely steady and free from the slightest sign of vibration or swaying. This observation also applies to the pentane lamp, which affords a flame of precisely similar character to that of the pentane air-gas. The improved pattern of this lamp, which is in no way altered as regards the principle of its operation, but is improved merely in matters of detail and adjustment, has afforded remarkably good results, and when it is properly working gives results identical with the air-gas flame. Table showing the total number of tests made, and the total and percentage numbers within 1 per cent. of the mean (excluding those given in the first report):—

Standard.	Total No. of Tests.	No. within 1 per cent. of the Mean.	Percentage No. within 1 per Cent. of the Mean.
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Keates's lamp	244	98	39
Pentane	468	373	80
Methven	283	211	74
Ten-candle test	49	43	88
Pentane Argand	243	212	87
Amyl-acetate	225	206	90
Pentane lamp	154	150	97
Total	2,120		

In view of the unmistakable results of the exhaustive series of tests conducted during this inquiry, I recommend that the committee do advise the Board to forthwith take such action as may be necessary to secure the adoption, with as little delay as possible, of the pentane air gas standard as devised by Mr. A. G. Vernon Harcourt, F.R.S., &c., as the legal standard of light in this country. As, however, many practical photometrists are of opinion that a standard of light of more than one candle is desirable for many purposes, I further recommend that when the legal substitution of the pentane unit for the present candle be made, the Board of Trade should be empowered to sanction and authorise the use of such other standards and substitutes as that Board may deem fit and proper to be used in place of and after comparison with the pentane air gas flame."

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Pentane lamp	154	150	97
Total	2,120		

In view of the unmistakable results of the exhaustive series of tests conducted during this inquiry, I recommend that the committee do advise the Board to forthwith take such action as may be necessary to secure the adoption, with as little delay as possible, of the pentane air gas standard as devised by Mr. A. G. Vernon Harcourt, F.R.S., &c., as the legal standard of light in this country. As, however, many practical photometrists are of opinion that a standard of light of more than one candle is desirable for many purposes, I further recommend that when the legal substitution of the pentane unit for the present candle be made, the Board of Trade should be empowered to sanction and authorise the use of such other standards and substitutes as that Board may deem fit and proper to be used in place of and after comparison with the pentane air gas flame."

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THE RISE AND PROGRESS OF TELEPHONY IN THE UNITED KINGDOM.

At a time when the electrical world has lately been engaged in the celebration of the Jubilee of the Electric Telegraph it will not be inopportune to take a survey of the rise and progress in our own country of one of its latest developments, namely, Telephony. It is not our intention to enter upon the interminable controversy as to who should or should not be regarded as the first, true and original inventor of the telephone, it will be sufficient for our purpose to state that as a commercial idea Telephony has now almost completed the first decade of its existence, and is therefore rather more than forty years younger than the telegraph. The English patent in which the invention of Prof. Graham Bell is set forth bears date the 9th December, 1876; the specification of Edison's carbon transmitter is dated the 30th of the following July, and the first public exhibition in this country of a working telephone was made by Mr. Preece at the Plymouth meeting of the British Association in the year 1877. At the meeting of the British Association held the previous year in Glasgow, Sir William Thomson had given an account of the researches in which Prof. Graham Bell was at that time engaged, and had excited great curiosity by the exhibition of an instrument (since known to fame as the Glasgow receiver), in which a diaphragm was attached at one side to the end of a cylindrical magnet. This receiver was exhibited in public prior to the issue of the patents, and hence is not covered by the specification; it was, however, of little or no practical value, and even Sir W. Thomson did not succeed in getting it to talk intelligibly. The exhibition by Mr. Preece twelve months later was, therefore, the first occasion on which the telephone spoke in public in this country.

Whoever may have been the first inventor of the telephone it is at least certain that the art of telephony is of American birth, and though its genealogy is to some extent to be traced in the annals of British science, yet we cannot claim as large a share in its origin as is justly awarded us in the earlier art of telegraphy. It is, however, well known that Prof. Graham Bell, although long resident in the United States, is by birth of British nationality, and when, in addition to this, we consider the indisputable fact of the priority of Prof. Hughes's discovery of the microphone, we have abundant reason for self-congratulation upon the part which our countrymen have borne in the origination of one of the most mysterious and beautiful applications of modern science, and one which from its flexibility and universality of adaptation gives promise of a future of as yet unknown importance.

At Plymouth, in the instruments exhibited by Mr. Preece, the Bell receiver was used also as a transmitter, the advantages of the carbon transmitter not having as yet been made known. The results obtained were thus comparatively feeble in character, and led for the time to the conclusion that the instrument could only be regarded as a scientific toy. It was this misconception which in all probability led to the rejection of the patent rights when offered to the British Post Office. The subsequent action brought by the department against the telephone companies (to which we shall refer later) is sufficient proof that a decided, though certainly an excusable, mistake was made in this refusal. What the present state of telephony would have been had the patents passed into the possession of the Government is scarcely a profitable subject for speculation; nor would it be altogether safe to assume that the Post Office would repeat in London the success which it has of late years undoubtedly achieved in Newcastle-on-Tyne

Be this as it may, however, about the end of 1877 Mr. James Brand proved himself more far-sighted or more enterprising than the Government, and succeeded in forming the Bell Telephone Company, which was registered in the following year, and of which Mr. Brand was the first chairman. The Bell Company was still without an efficient transmitter, the exchange system had scarcely been thought of, and it was by no means [illegible] everyone that the invention was capable of bearing a commercial value. However, the instruments were easily and cheaply made, and as the retail price was fixed at starting at £70 per pair, it did not need a very large volume of business in order to make a profitable return upon the investment. The first instruments made in this country, while the company was still in process of formation, were turned out by the Silvertown India Rubber and Gutta Percha Company, and before the close of 1877 a set of these was erected at Osborne by command of Her Majesty the Queen.

In the course of the following year—that is, not long after the formation of the company—it became evident that the sale of telephones for private use could not at any price be made the basis of so large a business as had been hoped for, and concurrently with the introduction of the "exchange" system (an American development) a resolution was arrived at which proved to be of the utmost importance to the future of the company, and, indeed, to the whole future of telephony in this country so long as the patents remain in force. The company determined to cease entirely from the sale of their instruments, and from that day to this no Bell telephones have legitimately changed hands save a certain number which had already been sold outright.

This action of the Bell Company has naturally given rise to unlimited grumbling, and is often harshly criticised; but while there can be no question as to the commercial shrewdness by which the policy was dictated, it should also be remembered for one thing that their instruments are of a description which it is excessively easy to pirate, and if indiscriminate sales were allowed it would be a matter of the greatest difficulty to ensure the payment of the royalties which the owners of the patent are entitled to charge. Our readers do not need to be assured that we are by no means in all respects apologists of the conduct of the telephone companies, but in this matter we are inclined to think that they pursued a sound policy, to which no valid objection can be made.

In the meantime it had become evident that while the Bell telephone employed as a receiver posseses a delicacy and a flexibility which remains to this day nothing short of a marvel, yet it is quite incapable of generating an E.M.F. of suitable strength to be an efficient transmitter for exchange work. Edison had early perceived this weakness, and had set himself to devise a type of transmitter which would permit the employment of a battery current of any required strength. Not content with this, he determined also to produce some form of receiver in which the necessary vibration of the diaphragm should be actually enforced by mechanical means, and the function of the current should be reduced to the regulation or adjustment of these mechanical vibrations. The latter part at least of the problem so set was sufficiently remote from the available resources of electrical science to merit any amount of scepticism as to the possibility of its accomplishment. But the indomitable perseverance and the fertility of resource of the American inventor triumphed over every difficulty, and before the close of the year 1878 the carbon transmitter had been re-invented, and the remarkable chalk-cylinder loud-speaking receiver had been brought into existence. That an electrical apparatus should be founded upon a property of chalk is certainly surprising. Edison was, however, aware that under certain conditions the friction between a moistened chalk cylinder and a tongue of platinum was lessened when a current passed through the point of contact in proportion to the strength of the current. This was sufficient foundation for his inventive capacity to build upon, and not only the loud-speaking telephone, but the equally remarkable phonograph was the almost immediate result. Without wishing in any way to detract from the credit due to Edison, it is, however, only fair to recollect that a telegraph based upon the variation of a frictional resistance traversed by the current was many years ago proposed by Bain, the inventor of the chemical telegraph, and to him the honour of the discovery of *one* of the principles employed by Edison in his receiver is certainly due.

[illegible] company was formed in this country to work these in[illegible] to compete with the Bell Company in the formation [illegible]xchanges. For a while the two companies proceeded

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on parallel lines, it being perfectly clear that their respective patents in no way interfered. But the Bell Company, realising the necessity of improving their transmitter, now adopted the so-called "Blake" instrument, in which a battery was employed in conjunction with a platinum-carbon contact. This was promulgated as a modification of Prof. Hughes's microphone, a discovery which, although of immense importance, he had magnanimously refused to patent. The Edison Company, however, asserted that Blake had infringed their rights in carbon transmitters, and legal proceedings were commenced. Before matters had reached any advanced stage the experience of the Edison Company had led them to perceive that, notwithstanding its louder tones, the complication of clockwork in their receiver, the necessity for keeping the cylinder moist, and the difficulty of maintaining a proper adjustment, placed them at a distinct disadvantage, which would perhaps more than counterbalance the superiority of their transmitter, even if they obtained the exclusive right to the use of carbon. In fact, notwithstanding the beauty and ingenuity of the Edison receiver, it never was a good commercial appliance, and has now, so far as we are aware, entirely disappeared from the scene.

These considerations on either side led to a withdrawal from legal proceedings and the foundation on May 1st, 1880, of a new company which bought up both the Edison and the Bell patents, and became known under the title of the UNITED TELEPHONE COMPANY. The two original companies went into voluntary liquidation, and the board of the United Telephone Company was in part made up of directors from both the former, Mr. Brand retaining his position as chairman. The Bell Company received £200,000 as the entire purchase money, and the Edison received £115,000. At the time of the amalgamation the annual rate of subscription to the Bell Telephone Exchange had been fixed at £20, and about 400 subscribers were in connection. The Edison Exchange had about 200 subscribers, and were charging £12 per annum. It should also be mentioned that the officers of the two companies were retained to form the working staff of the new company, and Mr. Thomas Fletcher, the electrician to the Bell Company from the commencement of its operations, was appointed chief engineer to the United. The Edison instruments were replaced by the Bell receiver and the Blake transmitter, and the subscription was fixed at £20 per annum.

Shortly after the formation of the United Telephone Company Major Joseph Bond Morgan, who had been chiefly instrumental in making the telephone a practical and commercial success at Liverpool, where an exchange was already at work, became managing director of the company, a position which he still continues to hold. The Liverpool exchange, it may be mentioned, was at that time, and has continued to be ever since, the largest in this country—that is to say, it possesses the largest number of subscribers connected with a single centre.

(To be continued.)

THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 201.)

The weights of the various parts of the foregoing machine will be as follows:—

Armature core	105 lbs.
Field-magnets	500 ,,
Armature winding	22 ,,
Field-magnet winding	78 ,,

Thus, the total weight of materials required in the electrical construction of the machine is—

Iron	605 lbs.
Copper	100 ,,

The electrical resistance of the armature will be ·0448 ohm, in which, with a total current of, say, 105 amperes, the loss would be 497 watts per second. Checking this figure by the surface presented by the armature core, and allowing 1 watt per second per square inch, we get 503 watts per second total loss.* From the current density and weight of copper in the field winding we find the loss there to be 266 watts per second. The total rate of work is thus, say, $10,000 + 770 = 10,770$ watts per second, and the electrical efficiency is $\frac{10000}{10770} = 93$ per cent.

With regard to the electrical efficiency of dynamos, we have seen that the work done in the armature winding in a given time can be expressed by the product $a R^2$, where a is constant for all machines of one type. Similarly, the work done in the field winding must be in proportion to the cooling surface. It has been shown that the length of the magnet cores varies as $R^{\frac{2}{3}}$, where μ is supposed to have an average value, or, more strictly, where μ is constant. Where μ varies, the length of cores will vary as $\frac{R^{\frac{2}{3}}}{\mu^2}$, the depth of winding being independent of variations in μ. The sectional area of the cores varies as R^2; thus the surface varies as $\frac{R^{\frac{5}{3}}}{\mu^2}$, and the work done in a given time is $b\frac{R^{\frac{5}{3}}}{\mu^2}$ where b is constant. Finally, the total work in the circuit has been shown to vary as $\mu R^{\frac{5}{2}}$ with constant peripheral velocity, and can be written $c\mu R^{\frac{5}{2}}$.

The electrical efficiency is thus:—

$$\text{Efficiency} = \frac{c\mu R^{\frac{5}{2}} - a R^2 - \frac{b R^{\frac{5}{3}}}{\mu_1^2}}{c\mu R^{\frac{5}{2}}}$$

where μ and μ_1 refer to the armature and field winding respectively.

The above expression can be of no practical use unless μ and μ_1 are written as functions of R, and under certain conditions this can can be done. We will deal with the two cases which occur most frequently in practice, viz., those of constant E.M.F. and of constant current. The latter conditions will not need any further calculation because μ will be constant, whilst the constants a, b, and c can be found when once a machine is designed.

The condition of constant E.M.F., however, introduces important modifications.

We have from equation (7) the section of wire

$$A \propto \frac{\mu^2 R^2}{N},$$

and from (6)

$$N \propto \frac{1}{n R^2},$$

but with constant peripheral velocity

$$n \propto \frac{1}{R};$$

$$\therefore N \propto \frac{1}{R} \text{ and } A \propto \mu^2 R^3$$

we will write $A = d\mu^2 R^3$ . . . . . (1*b*)

where d is a constant.

With regard to the form of the section A, it is clear that the greatest advantage will be secured when it is square; in any case, μ could be written as a function of $\sqrt{A}$, and since practical facilities do not forbid the use of square wire, we shall put

$$\mu = \frac{\sqrt{A}}{\sqrt{A} + \cdot 05}.$$

$$\therefore \mu^2 = \frac{A}{A + \cdot 1\sqrt{A} + \cdot 0025},$$

substituting in (1*b*)

$$\mu^2 = \frac{d\mu^3 R^3}{d\mu^2 R^3 + \cdot 1\sqrt{d}\,\mu R^{\frac{3}{2}} + \cdot 0025};$$

* Or allowing ·9 watt per sq. in. only, the total current must be restricted to 100 amperes.

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thus $$d\,R^3\mu^2 + \cdot1\sqrt{d}\,R^{\frac{3}{2}}\mu + \cdot0025 - d\,R^3 = 0.$$

Whence $$\mu = \frac{-\cdot1\sqrt{d}\,R^{\frac{3}{2}} \pm 2\,d\,R^3}{2\,d\,R^3};$$

and since the + sign only need be considered

$$\mu = 1 - \cdot05\,d^{-\frac{1}{2}}\,R^{-\frac{3}{2}} \quad . \quad . \quad . \quad . \quad . \quad (2b)$$

In a similar manner it can be shown that

$$A = d\,R^3 - \cdot1\sqrt{d}\,R^{\frac{3}{2}} + \cdot0025. \quad . \quad . \quad . \quad (3b)$$

The total work done in the circuit per second will now be written $$W = c\,(R^{\frac{5}{2}} - \cdot05\,d^{-\frac{1}{2}}R) \quad . \quad . \quad . \quad . \quad (4b)$$

The section of wire in the field-magnets will be $A = e\,\mu_1^2\,R^3$ e being a constant; and since the section is to be taken as circular

$$* \quad \mu_1^2 = \frac{\pi}{4} \cdot \frac{A}{A + \cdot04\sqrt{A} + \cdot0004}$$

whence by making the proper substitutions and solving the quadratic as before

$$\mu_1 = \frac{-\cdot04\sqrt{e}\,R^{\frac{3}{2}} \pm \sqrt{\pi e^2 R^3}}{2\,e\,R^3}$$

$$= \frac{\sqrt{\pi}}{2} - \cdot02\,e^{-\frac{1}{2}}\,R^{-3} \quad . \quad . \quad . \quad . \quad . \quad (5b)$$

and $$\mu_1^2 = \frac{\pi}{4} - \cdot02\sqrt{\pi}\,e^{-\frac{1}{2}}\,R^{-\frac{3}{2}} + \cdot0004\,e^{-1}\,R^{-3}$$

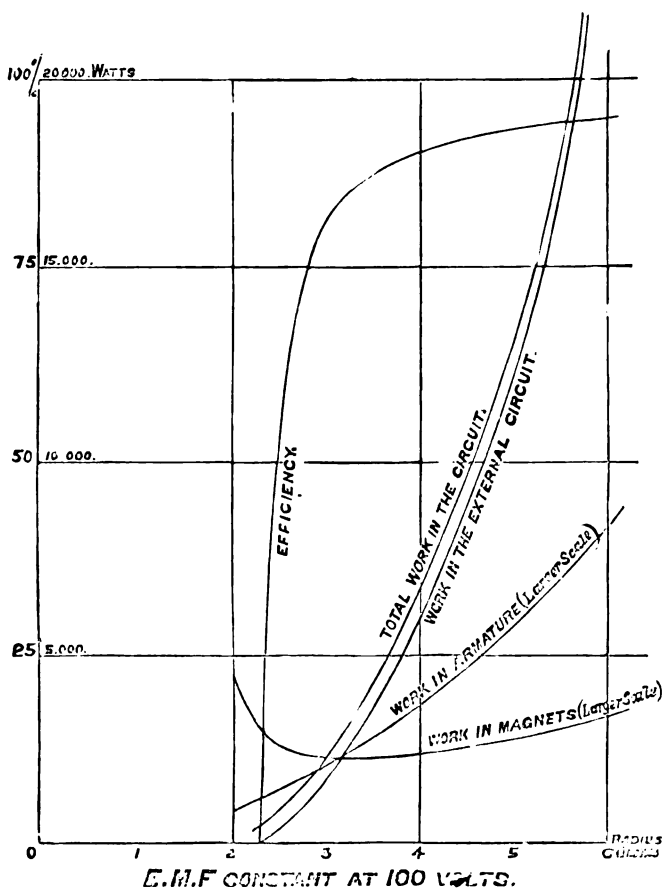

FIG. 14.

The electrical efficiency can now be expressed as a function of R only, and it is

$$\text{Eff.} = \frac{c(R^{\frac{5}{2}} - \cdot05\,d^{-\frac{1}{2}}R) - a\,R^2 - b\left(\frac{R^{\frac{5}{2}}}{\frac{\pi}{4} - \cdot02\sqrt{\pi}\,e^{-\frac{1}{2}}\,R^{-\frac{3}{2}} + \cdot0004\,e^{-1}\,R^3}\right)}{c(R^{\frac{5}{2}} - \cdot05\,d^{-\frac{1}{2}}R)}$$

Taking the E.M.F. at 100 volts, the constants a, b, c, d, and e may be deduced from the machine already designed, and are as follows:—

$$a = \frac{500}{R^2} = 23\cdot3$$

$$e = \frac{A_1}{\mu_1^2\,R^3} = \frac{\cdot00521}{\cdot504 \times 99} = \cdot000104$$

$$d = \frac{A}{\mu^2\,R^3} = \frac{\cdot0149}{\cdot533 \times 99} = \cdot000281$$

$$c = \frac{10770}{32\cdot16} = 334$$

$$b = \frac{270 \times \cdot4772}{12\cdot8} = 10\cdot1$$

In Fig. 14 a set of curves are plotted from the above figures; it will be seen from them that dynamos of this type to give 100 volts cannot be economically constructed with smaller radius than 3in., and that at a radius of 2·15in. the machine would refuse to do any work in the external circuit.

From equation (4b) we should find the output to be zero when

$$R^{\frac{5}{2}} = \cdot05\,d^{-\frac{1}{2}}R;$$

that is when $$R^{\frac{5}{2}} = 3\,R$$

or $$R = 3^{\frac{2}{3}} = 2\cdot08\text{in.}$$

The meaning of this is that at those dimensions the cross section of copper in the winding becomes zero, and μ vanishes.

As a matter of fact it would be possible to make somewhat smaller generators than here indicated, but it would be done only by using thinly insulated wire, and by increasing the speed or heating co-efficient. Smaller machines of lower E.M.F. could, of course, be made.

For the sake of convenience in reading, the curves showing the rate of work in armature and field-magnet winding are drawn to ordinates ten times higher than those to which the curves of total work are drawn; it is interesting to note that there is a point of inflexion in the field-magnet curve.

(To be continued.)

LIGHTING ENGINE FIRES BY ELECTRICITY.—At a recent meeting of the Chicago Association of Master Mechanics a communication was read from Mr. J. Leonard on the subject of "Locomotive Preparation," in which a question was raised as to the practicability of employing electricity in "firing up" locomotives with a view to economy of time and fuel. Assuming that the locomotive shed already possesses an electric lighting plant Mr. Leonard was of opinion that such an arrangement is "entirely feasible." After referring to the Cowles electric furnace, he expressed a preference for a low tension method as being safer and probably more economical; but considering that there are comparatively few railroad shops in America provided with incandescent machines, while arc circuits are plentiful, he thought it would be interesting to consider under what condition the arc lamp current could be used. The paper concludes as follows:—"1. The apparatus should be rendered perfectly safe by being heavily insulated to prevent short circuiting through the person handling it. 2. It should be fitted with flexible wires, so as to reach any part of the roundhouse; and 3. It should be small enough to readily pass in and out of the furnace door. These it seems to me are the most essential qualities that such an apparatus should possess, and I believe can be readily combined by the use of a V-shaped frame with three pairs of carbons connected in series and switch placed high enough on the two conductors to cut off the current from that part of the apparatus likely to be handled. Of course it would be necessary to properly insulate the carbons, the first charge of coal, and the apparatus itself from the end of the boiler in order to prevent the loss of current to and through the ground. This could be done by using a plate of, say, slate or asbestos for the base of apparatus, long enough to hold the coal to be ignited."

* ·02 only is allowed for covering in magnet winding.

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THE OERLIKON ELECTRO-PLATING DYNAMO.

The dynamos designed by Mr. C. L. Brown, and built at the Oerlikon Engineering Works near Zurich, seem to have come into a good deal of favour upon the Continent, some seventy or eighty machines of various types having been installed within the last year or two. In general design these dynamos conform very closely to the Manchester type, the chief departure being in a direction which in our opinion scarcely commends itself as an improvement. This is in the winding of the armature, which is virtually a Pacinotti ring, but the wire, instead of lying in slots around the edge of the iron discs, is threaded through holes drilled close to the margin of the iron. The object of this arrangement is apparently to increase the mass of the armature iron in closest proximity to the field core. But although the magnetic resistance is somewhat reduced, it is apparent that the benefit thus obtained will be more or less counteracted by the fact that a certain number of lines can traverse the periphery of the armature without passing through the windings, and thus tend merely to increase the magnetic resistance of the whole of the field iron. It is clear, however, that the Oerlikon dynamos are well built and efficient machines; and we may remind our readers that they are now being shown at the Manchester Exhibition by Mr. Thwaite, of Liverpool, who has been appointed agent for this country.

The two adjoining figures illustrate the construction of an electro-plating machine of this type designed for an output of 50 horse-power at 350 revolutions, and to be capable of running day and night for considerable periods without intermission. The terminal E.M.F. amounts to 115 volts, and with a current of 440 amperes the rise of temperature in the armature after a run of 14 hours has been found to amount to about 60°C., and in the field to about 35°C. The machine is very substantially built, and weighs 6·5 tons. The field is shunt-wound, and is excited with 35,000 ampere turns, a figure which seems to be pretty high considering that there is only one layer of wire on the outside of the armature. The magnetic circuit is, however, rather long, and there would appear to be some opportunity for leakage between the horns of the pole-pieces, which extend, perhaps, a little too far. The electrical efficiency is given as 95 per cent. Fig. 1 is a central longitudinal section of the machine, and Fig. 2 is a vertical section in two planes.

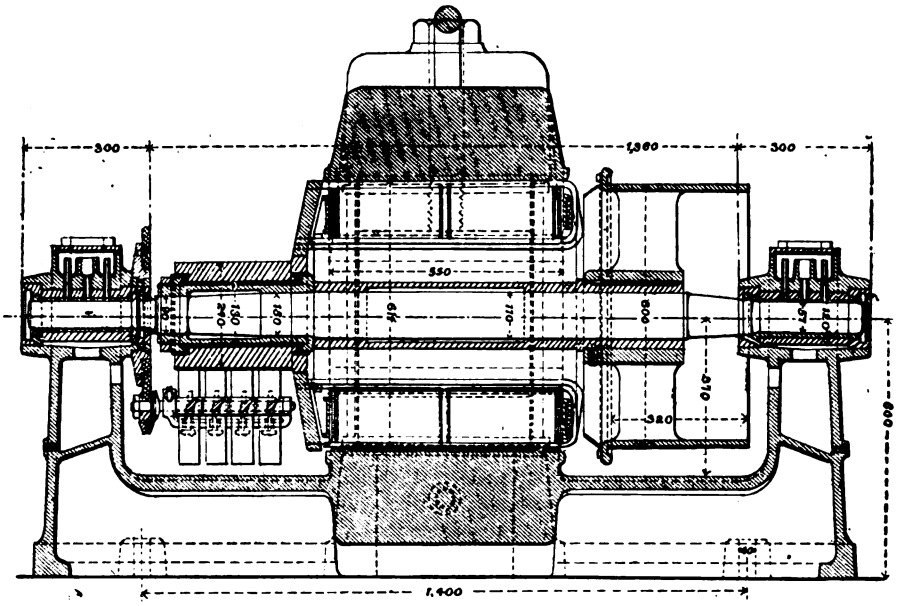

Fig. 1.—The Oerlikon Dynamo. Central Longitudinal Section.

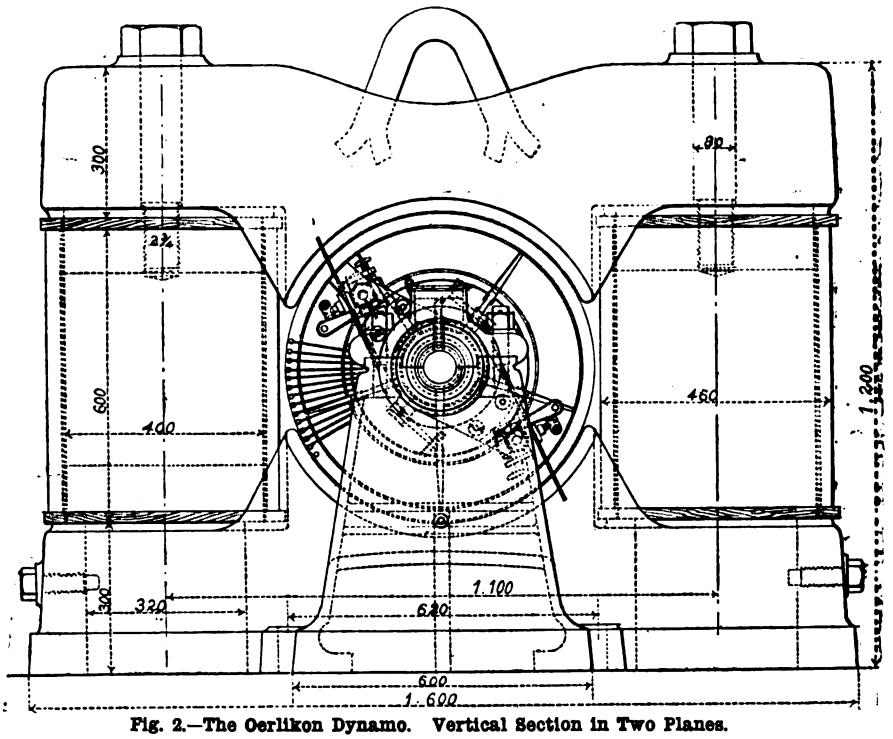

Fig. 2.—The Oerlikon Dynamo. Vertical Section in Two Planes.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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THE NAVAL MANŒUVRES AND THE TELEGRAPH.

Probably the best lesson we can derive from the mimic warfare which raged on our southern and western coasts last week is that these naval manœuvres ought to become an established institution, like the Autumn and Easter manœuvres on land. Our knowledge of what took place is limited by the fact that newspaper correspondents did not accompany either the attacking or defending squadrons; but sufficient information has reached us through trustworthy channels to prove that a good deal of useful work was done on both sides; and, what is of greater importance, that some of the weak links in our system of defence were made conspicuous. Perhaps on account of the circumstance just mentioned the experiment has not been very kindly handled by the press, which is always disposed to ridicule what it has no hand in describing. According to some of these organs the naval manœuvres were not only a sham, which undeniably they were, but a farce, which they certainly were not. This matter is set at rest by a perusal of the interesting and instructive account of a naval correspondent with Sir W. HEWETT'S Division published in last Monday's *Times*. If only we had a similarly complete report from Admiral FREMANTLE'S Division some of the points in which our readers are most interested would be made clearer. But even as it is we have sufficient evidence to show that in the matter of coast defence the Electric Telegraph plays but a very insignificant part. Visual signalling from shore to ship seems to have been as perfect as between ship and ship; but between the various land points separated beyond the reach of visual signals, where, if anywhere, we should expect electric signalling to be available, either it has no existence or it was very little used.

It is asserted by a correspondent of the *Globe* that even at the important position of Dungeness, which commands the southern entrance to the Straits, there is no electric telegraph. The statement seems incredible, but receives some confirmation in the fact that FREMANTLE'S attacking squadron, after dodging and leaving the defending fleet behind off Portland, actually was sighted at Dungeness steaming on to the Nore, while a flotilla of torpedo and gunboats off Deal remained in ignorance of the fact, and was passed with impunity. This would seem to imply that Dungeness possesses no means of signalling to Deal or to Dover, close by, neither of which is distant more than fifty miles! If this is the case, then we can only suppose that the wily FREMANTLE knew it, and hope that if ever his tactics are imitated by a hostile fleet its commander will *not* know it; or, better still, that before that day arrives we shall have frightened the British Government into spending the few pounds necessary to connect Dungeness with the inland system of telegraphs.

The *Globe's* correspondent's statement is borne out in general terms by the diary of *The Times'* naval correspondent. Making all due allowance for his evident desire to explain away the dense fog, despite of fine weather, in which the movements of Admiral FREMANTLE had left the defenders, we cannot but admit the justice of his comments on the defective signalling arrangements on land. "The immense importance," he says, "for the defence of our coast of joining all our principal coast guard stations, lighthouses, &c., telegraphically is being made evident at every move we make." Incidentally he mentions that it takes a full hour to get a message through from Plymouth to Portland. Had the defence been a real one, we may reasonably conjecture that not a tenth of an hour would be lost on such a service; but the existing route is certainly circuitous, and might easily be shortened. Of course an invading fleet would steer clear of the coast stations until it made up its mind for the point of attack. But the defenders would, as they actually did in this case, send out their fast cruisers as scouts; and the vital thing would be that the scout could make direct for any coast signalling station; and that this station should in turn be able to dispatch her visual signals instantly by electric telegraph to the port in communication with the defending squadron. We say this ought to be possible, but apparently at present it is not; for the accessible points are too far apart, and they are not all provided with the electric telegraph.

It has been urged that the defenders were not adequately supported by the land forces. But this is a misapprehension. The plan was not for a landing, but for a destructive raid upon either a fortified town or shipping port, ten hours' unmolested possession to constitute a successful bombardment. In the case of Falmouth—to say nothing of what was done on the western coast—this feat was accomplished; and by availing himself of the tide when the defenders—who arrived too late, owing to defects of coast signalling—could not follow him, Admiral FREMANTLE actually sailed up the Thames and got possession of Sheerness and the Medway. Whether he could have ever got out again is another matter. Now, for such a plan of operations the land forces were not necessary, because they would have been useless. All that was necessary was to add to the strength of the signalling stations; and this we learn was actually arranged, special signalmen having been placed along the coast between the Lizard and South Foreland. We may take it, therefore, that everything was done that in the event of a sudden descent upon the South coast could possibly be done. The result, though flattering in some respects, is not

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reassuring; and for one thing it is clear that our telegraphic arrangements as an instrument of national defence are far from satisfactory.

The chief service rendered to Sir W. HEWETT'S squadron was by "that very smart man," Lloyd's superintendent at the Lizard. He seems to fully answer the description given of him by his grateful admirer. Every vessel in the navy would appear to be known to him, and he penetrated their cunning disguises in a way that may naturally astonish us landsmen, seeing that they deceived all the sailors afloat in Admiral HEWETT'S squadron. But such preternaturally "smart men" are not plentiful; and, indeed, one of the enemy's ships, disguised as an ordinary paddle boat, sailed inshore between the defenders and the coast signalmen without being detected, and actually flashed a false telegram, which they innocently sent forward as genuine. At first sight this incident seems to tell against telegraphy, which lends itself to a daring ruse of that description; but in reality, if the less smart men at Tor Cross, Salcombe, could have seen with the eyes of the smarter man at the Lizard, who had spotted the pretended paddler some hours previously—in other words, if they had been in telegraphic communication with him—the impostor would have been captured instead of getting clean away, as she easily did. We have said that these manœuvres should be repeated periodically; but we hope that when next they take place such an exploit as this will be rendered impossible.

CORRESPONDENCE.

THE FORBES NON-POLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

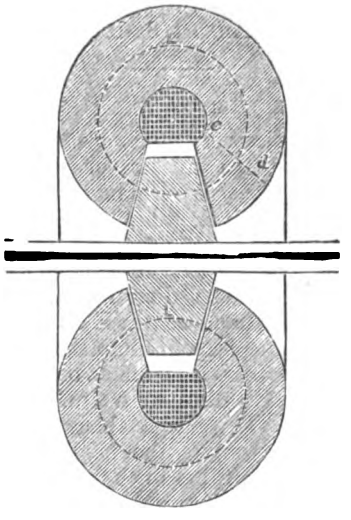
SIR: In the first paragraph of his last letter Mr. Scattergood points out that I have credited him with a meaning which he did not intend. Doubtless, he is the best judge of his own meanings, but my mistake was, I should say, a very natural one, for his first letter contained the statement that "the rotation of a cylindrical bar magnet about its axis does not induce a current in a fixed circuit situate in its field, *because the number of lines which pass through the circuit are unaltered by the magnet's rotation*, the field being symmetrical about the axis." Now, since he distinctly states his reason for the non-production of a current, the observation must be held to apply equally well to any circuit, whether fixed or not, so long as the number of lines passing through it does not change. *Ergo*, "a cylindrical magnet" (Forbes's field-magnet will do for this, and as there is no restriction with regard to contacts, we may suppose the machine to revolve around its armature) "rotated on its axis does not excite a current in a stationary conductor" (the Forbes armature) "situate in its field, while the conductor" (the armature) "itself, if rotated in the same way relatively to the magnet, does give a current." (I added the latter statement because it is well known that the Forbes machine gives a current.) Now, in neither case is there any "change in the number of lines of force embraced by the circuit." Mr. Scattergood will very likely take exception to this statement, for this is what he "emphatically" asserts is necessary in order to have any induced E.M.F. He dogmatically asserts that there is such a change, and, after devoting a paragraph or two to Mr. Voice, he describes an experiment to show that the number of lines passing through a circuit in an analogous case does change. What, may I ask, has the line "O C" in his sketch to do with the circuit? In which direction is the current there? And how does he apply such reasoning to the Forbes armature, which gives off current all round its perimeter, and is all circuit? Let him show us a real circuit in such a case in which the number of lines does not remain a constant quantity, in which the number of lines entering is not balanced by the number departing.

In the last three but one paragraphs of his letter he sets forth an experiment designed to ascertain whether the lines of force revolve in the manner I suggested. The result, I fear, would not settle the question. A needle situated as described will, of course, assume a position of equilibrium when all is stationary, and will not have that equilibrium disturbed by the rotation of the lines, unless the conditions are such as to allow a current to be produced within the needle's mass, for otherwise there is no reaction. The needle is situated in an invariable field, and the lines which traverse it are balanced in their attractions, the needle's poles attracting the lines approaching them with exactly the same force on one hand as the lines leaving them on the other.

I must accuse Mr. Scattergood of hair-splitting. I fully explained in my last letter what I understand by the term "magnetism" (which I often use, to save waste of breath, in preference to the term "magnetic force").

In the same paragraph I am represented as talking of "force possessing inertia." What I did say was, "may we regard" what he calls the magnetic force "as possessing infinite inertia with respect to rotation about the magnetic axis?" I will not, however, say—since Mr. Scattergood opens that question—that force does not possess inertia; it all depends. I know that force is sometimes inertia, but I do not make bold to offer an opinion what inertia is after that. There is a very good chance for Mr. Scattergood to perpetuate his name if he can tell the world what force is and what it is not. There is more in this than appears on the surface, and if he is sufficiently interested he might profitably turn to a correspondence on the laws of motion which appeared in *The Engineer* in the early part of 1885.

Now, Sir, I have sought information, which no one has been able to give me, and I have taken the liberty to suggest that the lines of force in the Forbes dynamo were only prevented from rotating as fast as the armature by a retarding force due to the generation of Foucault currents in the mass of the field-magnet and surrounding conductors. I have seen nothing in this correspondence to induce me to alter that view, but in thinking over the matter again it has struck me that the E.M.F.'s which would be set up in the field iron, &c., probably balance each other—that, in other words, there is no path open to currents.



Thus, suppose the figure to represent a longitudinal section through the axis of a Forbes machine. The dotted lines L L show the configuration of the lines of force which encircle the exciting coil, and lie in planes which intersect at the axis of the machine. Take *any* line *c d* within the mass of the field-magnet drawn outwards from the exciting coil. Now, suppose the armature to revolve and to drive with it the lines of force, an E.M.F. is at once produced on the line *c d* by the movement of the lines of force across it; but no current can circulate, as I take it, because the return path from the extremities *c* and *d* would necessarily be cut by the same

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number of rotating lines as *c d*, and a current would therefore be impossible, unless, indeed, it be supposed that a current flows back, so to speak, through the medium of those molecules which are not at any given moment occupied in the production of the E.M.F., for it may be presumed that only a portion of the matter is magnetically polarised unless there be absolute saturation. But if this be true, heating effects should be observable, and it would be interesting to know if heating has been observed under such circumstances. The question whether the molecular movements implied by the motion of the lines of force through such a mass—even if they do not produce an evident current—is not attended by the development of heat is, I believe, unsettled; but, assuming that there is a degree of molecular friction entailed, then undoubtedly the lines would encounter a corresponding degree of resistance.

Returning now to the figure, suppose that we have contacts arranged to bear against the points *c* and *d*, and connected by a conductor which revolves along with the lines of force, then since this conductor is not cut by these lines the potential at *c* and *d* will drive a current through the circuit. Similarly, if we suppose the armature to revolve through the lines of force without the collecting contacts being applied, we have nothing more than E.M.F. induced in it; but as soon as the sliding contacts are applied about the armature's perimeter and at its centre so as complete the circuit through a fixed conductor, as in actual practice, then a path is opened for a current. If the lines of force are driven round with the armature they must necessarily cut through the stationary conductor in the opposite direction to that in which they cut or tend to cut through the armature, so that the same E.M.F. will drive a current through the circuit whether the lines go round with the armature so as to cut the stationary conductor only, whether the lines remain stationary so as to cut the armature only, or whether the truth lies between the two. It is no matter, therefore, whether the lines are partly driven round with the armature contrary to what I at first supposed.

The ordinary rule, reiterated by Mr. Scattergood, that "no induced E.M.F." (much less current) "is possible without a change in the number of lines embraced by a circuit," is not applicable to this dynamo. That rule is only generally convenient because the rate at which lines enter or leave a circuit is an index of the number of lines which traverse the conductor composing it in the direction necessary to produce current.—Yours, &c.,

R. SNOWDON.

Staveley Ironworks, August 8, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I find Mr. Voice very anxious to prove that the pivot of the machine in question will not or practically will not be cut by any lines of force. Well, assume for argument's sake it is not cut by any lines, what then? The difficulty, as originally stated, was, how could current be produced in two conductors leading radially out of the field, as the inductive action being in the same direction in each they would naturally have an equal and contra E.M.F. when completed in circuit? And I then endeavoured to show that the E.M.F. induced at each disc of the machine as originally drawn would differ, inasmuch as these discs were situated in different positions of the field. Mr. Voice then stated he could get one of his conductors out of the field without being cut by any lines of force; but I have not to this moment been able to discover what this goes to prove or disprove.

As it appears that the explanation I have previously given of the cause of current in a disc machine has been imperfectly understood I will here repeat it; but previously to so doing I will assume that we are agreed as to the necessity of cutting lines of force, and that the E.M.F. of a conductor is dependent on the number of lines of force it cuts in a given time; or, otherwise expressed, with constant velocity the E.M.F. will be proportional to the density, and likewise with constant density the E.M.F. will be proportional to the velocity. In fact, if we substitute for velocity the temperature or heat energy applied to a gas, and for E.M.F. the pressure produced, we shall find that Marriotte's law is quite applicable.

Below I have given two diagrams. No. 1 represents in principle one of Faraday's experiments mentioned by De la Rive. The disc shown is of brass, and is insulated from the magnet, the current being taken off by the two conductors A and B. The disc I treat simply as a conductor, neutral to the action of the lines of force, inasmuch as it revolves with them. Now, the velocity of cutting varies radially throughout either of the conductors A or B, as also inversely the density, and as they vary in the same relative proportions—that is, as the squares of the radial distance—the same E.M.F. will be induced at any point along either of these conductors.

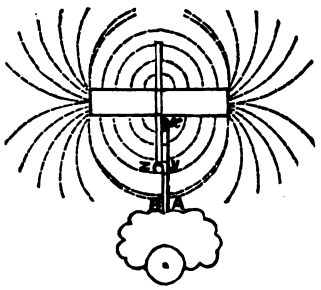

Diagram No. 1.

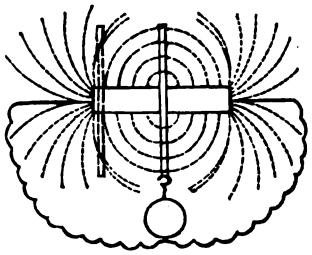

Diagram No. 2

All, then, that we have to consider is the simple fact that A has an additional cutting through the length extending from *y* to *x*, and hence, although the portion *z* B and *y* A have an equal and opposed force induced, we still have the excess of E.M.F. in *x y* to spare, which in this case is the true course of the current. No. 2 shows Weber's machine, in which the disc is in electrical connection with the magnet. Here it is evident that the conductor at the centre could cut more lines of force than the pivot at the end, and that a higher E.M.F. would be generated in the former. If, however, the disc be placed at the end as shown dotted I would expect a reduction in E.M.F., and I cannot see how Weber could get otherwise when he states that "the absolute effect was considerably less," especially as the resistance may be reduced by coupling the disc to the near end of the magnet.

This diagram will also serve to show how Mr. Voice obtained current off the two discs of his first machine. If I remember rightly, Mr. Voice was of opinion that the two discs would be each under the same degree of inductive influence.

Will Mr. Voice, then, please explain on his own theory how current can be produced in two discs under the same inductive influence when revolving on the same magnetic axis?

I believe I am correct in stating that there are those who hold that a conductor must move in a field of varying influence. I do not myself see the necessity, but it is a point I should not like to be too dogmatic about.

It seems to me that as all machines have by necessity of construction varying fields, we have no disproof of the contrary assumption. The fact of inducing different degrees of potential along the line of the conductor cannot determine the directive action of the current, as is seen in the case of disc machines, for on this theory we would expect the directive action to be the result of a flow, so to speak, from a point of high potential to that of a lower potential, whereas in a disc machine the contrary may take place. The direction, then, of a current would appear to be determined by the action of the molecules themselves. If the two conductors in diagram No. 1 were taken up vertically and approximately in the same plane as shown, they would be, as previously stated, under a uniform inductive influence, and here would be a proof that a varying inductive influence on a conductor is not necessary.

Of course, by this theory the necessary molecular oscillations are ascribed to the conduct of the field itself; it is assumed that its structure, be it that of concentric waves or a bundle of parallel vortices, is such as to impart these oscillations when cut by a conductor in the orthodox fashion. I cannot see how the fact of the current being double when both pivots are coupled to the circuit in any way proves or disproves Mr. Voice's independent field theory, and I purposely avoided referring to this again, as it seemed to me to

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be only waste of time and space. Even if it was important, we are informed of a fact without any data whatever as to galvanometer resistance, &c. Of course I should expect the result to be two if there was no galvanometer resistance, but Mr. Voice seems to think that parallel paths give double resistance. I appear to have misunderstood Mr. Voice's question about the Gramme ring. He now states that "when a mass of iron is moved in a magnetic field currents are produced in it transversely to the direction of such movement by reason of conductivity, and the mechanical resistance is caused, not by the difficulty of the iron passing through the lines of force, but by another kind of force—electricity—being formed in it, which acts on the magnetism." May I ask how a quality such as conductivity can in itself be a cause of action? We might with equal truth say a corkscrew will draw a cork because it is of suitable form, and therefore no force is necessary.

Mr. Voice touches on a difficult subject when he refers to the free action of a non-conductor in a magnetic field. The quality conductivity is apparently that which determines the efficiency of induction or the quantity of mechanical force that will be transformed into electrical action. If, then, the resistance of the field reacts on the molecular constitution of the conductor, how is it that non-conductors are not subjected to the same action? The only satisfactory answer to this question is that the molecular porosity of a non-conductor is such that the ether has free action through its interstices. To conceive such phenomena possible when the body is in motion, we must assume the atoms of the ether field to possess an infinitely higher velocity than any mechanical movement we can impart, and hence with a given molecular porosity the transmissive action would be almost as good when the body is in motion as when at rest.

We might then expect bodies of a dense nature such as copper to obstruct when in motion the due action of the magnetic field, and thereby produce current. The subject, of course, is fraught with many difficulties, and is of a very speculative nature, and I wish it to be understood that the action I have endeavoured to trace above is that of a body cutting the lines of force only, and is not intended to apply to its behaviour when moved parallel to their course.

As Mr. Voice still believes in an independent field, I will ask him to inform me how it is that current is produced in a copper disc revolving between two magnetic poles, the periphery of the disc being below the axis of the poles? If the magnetic field between these poles were free to move around its axis, where would be the resistance to the movement of the disc?

But Mr. Voice must first clearly understand that where force is applied resistance must be opposed if work is to be done. Again, I might point to the fact that a polarised ray of light travelling along the axis of a stationary magnetic field receives a spiral twist. What is the action that gives it this twist? Clearly the field. How, then, can the field produce a rotating strain if it were perfectly free to revolve?

There appears to me to be one feature in the action of a Gramme armature that gives some colouring to Mr. Voice's theory. I refer to the reflex field produced by the current passing through the coils of the bobbin. Such a field would have its axis lie between the two brushes, and it would seem at first sight that as these brushes are fixed and the position of the field secured we have a case where the tangible part of an electro-magnet is revolving through its own field. But it would be more correct to say that the coils could not pass through lines that are produced by their agency, and that hence the lines of force of this field are actually revolving with the coils, although the total effect as a whole is that of a field having its poles situated at the brushes.

Mr. Voice, I notice, repeats an isolated sentence of mine, "Why have a core at all?" and proceeds to argue as though I were ignorant of the use of an iron core in an electro-magnet. If he will please re-read my letter he will see I was referring only to a permanent magnet, and the question was asked in conjunction with his theory that such a magnet would possess an independent field. The term core was not perfectly correct, but I used it to distinguish between the magnet as a whole and the steel constituting its material part.

I do not clearly follow Mr. Scattergood's explanation of the production of current in the machine under discussion, and I do not think he is correct in defining a magnetic field. As a field of force only there is something more material about it. Force is not conceivable as a quality in itself, *i.e.*, independent of mass; and it is the ether atoms or molecules under the influence of force that constitute, in my opinion, a magnetic field.—Yours, &c.,

N. G. THOMPSON.

4; Queen Victoria-street, E.C., Aug. 10, 1887.

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XLIV.

BY OLIVER HEAVISIDE.

Any number of non-distortional circuits radiating from a centre, operated upon simultaneously. Effect of intermediate resistance: transmitted and reflected waves. Effect of a continuous distribution of resistance. Perfectly insulated circuit of no resistance. Genesis and development of a tail due to resistance. Equation of a tail in a perfectly insulated circuit.

If the ends of the two conductors of a non-distortional circuit at its termination at A be caused to have a difference of potential V_0, varying in any manner with the time, and if there be an absorbing resistance inserted at the other termination B, we know that the impedance of the circuit to V_0 is Lv, a constant, at every moment, so that the current there is V_0/Lv. We also know how the potential-difference and current are transmitted, attenuating to $V_0\rho$ and $V_0\rho/Lv$ on arrival at B.

If there be a second non-distortional circuit starting from A, and we simultaneously maintain the same difference of potential V_0 on it, we know what happens on it, viz., as above described, merely changing, if necessary, the values of ρ and Lv. That is, if the circuit be not of the same type as the first one, and of the same length, we require to use different values of ρ and Lv.

This obviously leads to the working of any number of non-distortional circuits in parallel by a common impressed force at A. Call the wires of a circuit the right and the left wires, merely for distinction. Join all the right wires to one terminal A_1, and all the left wires to another, A_2, and then maintain a difference of potential V_0 between A_1 and A_2. Then, provided every circuit has its proper absorbing resistance at the distant end, we know what happens. The reciprocal of the sum of the impedances of the various circuits is the effective impedance to V_0. Next, V_0 divided by the effective impedance (say I), is the total current. Finally the total current divides amongst the circuits in the inverse ratio of their impedances. The current at the distant end B of any circuit is the current entering it at A at the time l/v earlier, multiplied by the attenuation-factor ρ of the circuit. I do not write out the equations, as the descriprion is fully equivalent.

In order that V_0 should be strictly proportional to an impressed force e in the branch joining the two common terminals A_1, A_2 of the circuits, it is necessary that it should be a mere resistance, which may have any value. Let it be R_0; then, R_0 added to the previous effective impedance to V_0, is the impedance to e; so that the total current is $e/(R_0+I)$, and the value of V_0 is $eI/(R_0+I)$. In practice it is not possible to fully realise this simplicity. Supposing, for instance, the secondary of the transformer, in the circuit of whose primary a microphone is placed, be joined across the common terminals of the circuits. Even if the circuits be non-distortional, we see that there must be terminal distortion, or V_0 will not vary as it should for the accurate transmission of speech. There are several causes of distortion here. At the distant end, one cause of further distortion will be the inductance of the receiving telephone, and an additional and very important one will be the mechanical troubles that will prevent the disc from copying accurately in its motions, the magnetic force variations.

After this example of a complex arrangement of circuits admitting of simple treatment, let us return to a single circuit. Examine the effect of inserting any resistance r intermediately.

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This should be put half in each wire, if the circuit consist of a pair of equal wires, to prevent interferences. Let there be a wave travelling from left to right towards r. Let V_1, V_2, V_3 be the potential-differences in corresponding portions of the incident, reflected, and transmitted waves, so that, at a certain moment, they are coincident, viz. at r itself, where let V be the actual potential-difference on the left side of r. Then we have

$$\left.\begin{array}{ll} V_1 = LvC_1, & V_2 = -LvC_2, \quad V_3 = LvC_3, \\ V_1 + V_2 = V = rC_3 + V_3, & C_1 + C_2 = C_3. \end{array}\right\} \quad (36d).$$

These are the full connections. From them,

$$\frac{V_2}{V_1} = \frac{r}{r+2Lv}, \quad \frac{V_3}{V_1} = \frac{2Lv}{r+2Lv} = \sigma \text{ say.} \quad . \quad (37d).$$

Particularly notice that

$$V_1 = V_2 + V_3, \quad . \quad . \quad . \quad . \quad . \quad (38d),$$

as this is an important property. Every element of electrification in the incident wave arriving at the resistance is split into two (without any loss), one part σV_1 (in terms of potential-difference) is transmitted, the remainder is reflected.

As we have, by (37d)

$$r = 2Lv\,(\sigma^{-1} - 1), \quad . \quad . \quad . \quad . \quad (39d).$$

we see that if 1 per cent. of the incident wave be reflected, and 99 per cent. transmitted, we require $r = \frac{2}{99}Lv$. If 10 per cent. be reflected and 90 per cent. transmitted, then $r = \frac{2}{9}Lv$.

There is no transmitted wave if r be infinite. Half is transmitted and half reflected when $r = 2Lv$.

There is always a loss of energy by this division of the charge, which is accounted for by the Joule heat in the resistance. This is rC_3^2 per second; and since a wave of unit length takes v^{-1} second to pass, rC_3^2/v is the loss of energy per unit length of the incident wave, which loss, if added to the sum of the energies in the reflected and transmitted waves, makes up the energy per unit length in the incident. Another expression for the loss of energy is given by

$$\frac{rC_3^2}{v} = \frac{4V_1^2 r}{v(r+2Lv)^2} \quad . \quad . \quad . \quad . \quad . \quad (40d).$$

There is the greatest possible loss of energy when $r = 2Lv$, making $\sigma = \frac{1}{2}$, and the loss $= \frac{1}{2}SV_1^2$. That is, when the intermediate resistance is twice the critical, and the incident wave is consequently half transmitted, half reflected, then half the energy is wasted in the resistance. As the resistance is further increased, the transmitted wave gets smaller, and when it is infinite, we fall back upon the case already considered of total reflection without reversal of electrification or loss of energy.

If we have the absorbing resistance at A and at B, and any resistance r at an intermediate point C, we have a very simple result when any waves are sent from A to B, or from B to A. Suppose e acts at A, and that ρ_1, ρ_2 are the attenuations in the two sections AC and CB. Then $V_1 = e$ at A becomes $V_1 = e\rho_1$ on arriving at C. The reflected wave is $V_2 = e\rho_1(1-\sigma)$, where σ is given by (37d). On arrival at A it is absorbed, so there is an end of it. The transmitted wave at C is $V_3 = e\rho_1\sigma$, which attenuates to $V_3 = e\rho_1\sigma\rho_2 = e\sigma\rho$ on arrival at B, where it is absorbed. The last equation therefore gives the potential difference at B in terms of that at A at the time l/v earlier. In the first section of the circuit V is the sum of two oppositely travelling waves, and the current is their difference divided by Lv; but in the second section there is but one wave.

We are also able to solve by algebra alone the following problem. Given a non-distortional circuit with any terminal resistances and any intermediate resistances at different places, find the effect due to a steady impressed force inserted anywhere in the circuit (half in each wire, pointing oppositely in space, to avoid interferences). For we have the circuit divided into sections, for each of which the attenuation is known (*i.e.* $\rho_1 = \epsilon^{-Rx_1/Lv}$ in a section of length x_1); we also know the transforming factors of the terminal resistances (ρ_0 and ρ_1 of the last section); and we also now know the factors σ and $1-\sigma$ for any intermediate resistance, by which we express how a wave divides there. So, starting when e is first put on, with the initial waves $\frac{1}{2}e$ to the right, and $\frac{1}{2}e$ to the left, we can follow the whole course of events until we arrive (asymptotically) at the steady state. But it is no part of my intention to enter into the details, as nothing new would be contained therein.

But the effect of a great number of equal intermediate resistances equidistantly situated is of importance. Let ρ_1 be the attenuation due to the circuit between two consecutive resistances, and σ the attenuation due to each resistance, that is, the attenuation of the transmitted wave. Let an isolated disturbance go from A to B. If it be initially V_0, it becomes $V_0\rho_1\sigma$ one section further on, $V_0(\rho_1\sigma)^2$ after another section is passed, and so on, becoming $V_0\rho_1{}^n\sigma^n$ after passing n sections. If these n sections make up the whole circuit, then $\rho_1{}^n = \rho$, the attenuation in the circuit due to itself only, as before, so that in passing through the circuit, V_0 is attenuated to $V_0\rho\sigma^n$.

Now let the sum of the inserted resistances be $nr = R_1$. Increase n indefinitely, whilst reducing r in the same ratio, thus keeping R_1 constant. In the limit the resistance R_1 becomes uniformly distributed in the circuit, and the attenuation due to it becomes, by (37d),

$$\sigma^n = (1 + R_1/2Lvn)^{-n}, \quad \text{with } n = \infty,$$
$$= \epsilon^{-R_1/2Lv} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (41d)$$

Observe the presence of the 2. From this we may conclude certainly (as will be shown later), that if this uniformly distributed resistance R_1, in addition to the original Rl, be accompanied by uniformly distributed leakage-conductance of total amount K_1, such that $R_1/L = K_1/S$, the attenuation due to both R_1 and K_1 together is expressed by the square of (41d). For what we do is to make the circuit non-distortional again, by the additional leakage to compensate the additional resistance of the wires.

But the simplest way of viewing the matter is to start with a perfectly insulated circuit of no resistance. This is a non-distortional circuit, of course, since it obeys the law $R/L = K/S$. The only difference from a real non-distortional circuit is that there is no attenuation at all. All the preceding results therefore apply, remembering that $\rho = 1$, or any waves are transmitted, not merely undistorted, but also unattenuated. They are, in fact, purely plane waves of light (very long waves practically) travelling through a perfectly non-conducting dielectric. They are merely guided through space in a definite manner by the conductors, imagined to have no resistance, so that, to use a very gross simile, the electricity slips along like greased lightning. There is no penetration of the electromagnetic field into the conductors, but purely surface conduction, where we may use the word in a popular sense (conduct = to lead). Some curious consequences of the absence of resistance I will notice later; at present I may observe that owing to the relative simplicity produced by the absence of attenuation, the imaginary circuit of no resistance is useful for investigating the effect of inserting resistances, bridges, &c., and the action of a real non-distortional circuit itself.

Thus, imagine an isolated charge moving from left to right in the circuit of no resistance. Introduce anywhere a resistance r; this will cause an attenuation from 1 to σ in passing the resistance (equation (37d)) and the remainder $1-\sigma$ will be reflected back. Next let there be a great number of equidistant small equal resistances; every one of these will attenuate in the ratio $1 : \sigma$, and throw back the fraction $1-\sigma$. The result is that the original isolated charge, as it travels along, becomes a nucleus with a long slender tail behind it; the nucleus travelling forward at speed v and attenuating in the manner described; the tail stretching out the other way at speed v. If these isolated resistances be packed together very closely, and be each very small, we approximate to the effect of continuously distributed resistance, that is, the resistance of the wires in a real circuit. In the limit, the result is, by (41d), that the nucleus, if originally represented by $V_0 a$, that is, the potential-difference V_0 through the very small distance a, with current to match viz., V_0/Lv through the same distance a, and therefore moving entirely to the right at that particular moment, becomes attenuated to

$$V_0 a.\epsilon^{-Rx/2Lv} = \epsilon^{-R/2L}.V_0 a \quad . \quad . \quad . \quad (42d),$$

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in the time $t = x/v$, during which it has moved through the distance x to the right, if the resistance per unit length be R.

Since there is here no leakage, the rest of the original charge must be in the tail. The amount of electricity in the tail is therefore

$$S \times V_0 a(1 - \epsilon^{-Rt/2L}), \quad . \quad . \quad . \quad . \quad (43d),$$

when the circuit is perfectly insulated. The length of the tail is $2x$, half being to the right and half to the left of the position of the original isolated charge, it being of course supposed that neither the head nor the tail has suffered any extraneous operations, as terminal reflections, &c.

In a similar manner, if initially the isolated charge SV_0a be without current, so that it would, were there no resistance, at once divide into equal halves, travelling in opposite directions without attenuation, what will really happen will be an immediate splitting into halves and separation of two nuclei, travelling in opposite directions at speed v, attenuating as they progress according to (42d), and joined by a band, consisting of the two tails superimposed. The equation of this double-tail is

$$V = \tfrac{1}{2}V_0 a \,.\, \epsilon^{-Rt/2L} \,.\, \frac{1}{v}\left(\frac{R}{2L} + \frac{d}{dt}\right) J_0 \left\{ \frac{R}{2Lv}(x^2 - v^2t^2)^{\frac{1}{2}} \right\}, \; . \; (44d)$$

in a finite form (as usually understood, by a convention that a solution in terms of a sine or J_0 function, &c., is in a finite form, though it is really an infinite series), true from $x = -vt$ to $x = +vt$, it being supposed that the origin of x was the original position of the charge. At the ends of this tail the two nuclei, each represented by

$$V = \tfrac{1}{2}V_0 \epsilon^{-Rt/2L} \quad . \quad . \quad . \quad . \quad . \quad (45d)$$

through the very small distance a, must be placed, to make up the complete solution. I shall later illustrate this graphically, and also explain the other kind of tail.

(*To be continued.*)

LITERATURE.

Electro-Deposition: a Practical Treatise on the Electrolysis of Gold, Silver, Copper, Nickel, and other Metals and Alloys, &c., with several Chapters on Electro-Metallurgy. By ALEXANDER WATT. Second Edition, revised and corrected. [London: Crosby Lockwood and Co., 1887.]

This book is manifestly written by a practical electro-plater, or by one who has spent a large period of time in manufactories of electro-plate. It is essentially and conspicuously a "rule of thumb" manual, and contains a very large amount of such information as comes within the capacities of the ordinary British workman. With great industry the author has collected a multitude of details respecting electro-plate workshop manipulation, the preparation and treatment of nearly all kinds of objects requiring to be coated electrolytically with metal, and especially respecting the electro-plating of them with nickel; and the latter appears to be the department with which he is the most familiar. The subject matter of the book is conveniently divided into chapters of moderate dimensions, and the contents of each paragraph are distinctly indicated by bold headings. The printer's errors are not numerous, and, with some exceptions, the information generally in the book is fairly up to date. The index is copious, and extends to about fifty pages.

The author is conscious of the necessity and advantage of theoretical knowledge to the working electro-depositor, for in the preface of his book he mentions "the chemical and electrical principles of electrolysis, the knowledge of which is essential to those who would practise the art of electro-deposition with economy and success;" and on page 80 he says:—"It is necessary, in the present advanced state of electrical science, that both the student and the practical operator should be acquainted with the principles and laws which govern the development of electricity—that *force* or *power* with which he has to deal in all electrolytic operations."

Notwithstanding these admissions of the necessity of fundamental knowledge of chemistry and electricity as relating to electro-deposition of metals, the book is seriously deficient in the chemical, the thermo-chemical, the electro chemical, and the voltaic principles of the subject. From beginning to end of the work the chemical, voltaic, and electro-chemical equivalents of the elementary substances, and their respective amounts of thermal energy, are not given or explained. On page 72 it is stated that "The decomposing effects produced by the voltaic current in different electrolytes are precisely in accordance with the *atomic-weights* or *chemical-equivalents* (which see) of the substances electrolysed." "For example, the same amount of electricity that would reduce 56 parts of iron from its solution to the metallic state would reduce 207 parts of lead or 108 parts of silver." But the "*equivalents*" referred to are not given anywhere in the book. On page 513 there is a table of atomic-weights of the chemical elements, but not of equivalents, nor is the reader informed that the two are in many cases widely different from each other; the only sign given that there exists any difference between *chemical-equivalent* and *atomic-weight* is in a foot-note to the table on page 513, saying "the combining-*weight* of oxygen is 8." Further, "the same amount of electricity that would reduce 108 parts of silver from its solution to the metallic state" would *not* "reduce 56 parts of iron," nor would it "reduce 207 parts of lead;" these proportions are the *atomic-weights* and *not* the *chemical-equivalents*; either the amount given of silver is only half the proper quantity, or those of iron and lead are double the correct amounts. In Chapters V. and VI., relating to the "Theory of Electrolysis," and "Electrical Theories in their Relation to the Electro-deposition of Metals," nothing is stated respecting the important relations of electrolysis to the amounts of heat evolved and absorbed by the chemical changes continually occurring at the electrodes in the electrolysis vessels, and at the surfaces of the battery plates in the voltaic cells, and upon which depend the quantities of electric energy which must be supplied in order to produce electrolysis; nor is any table given of the amounts of heat evolved and absorbed in chemical and electro-chemical actions.

In consequence of the omission of the chemical equivalents of the elements, and the absence of any correct technical rule based upon them, the depositor is not enabled to calculate what quantities of the respective acids, bases, or salts, he must take in order to make or correct his various solutions, but must trust to some "rule of thumb" method. He is not shown the way to calculate how much acid or zinc must be consumed in his voltaic battery in order to deposit a given weight of silver in the electrolytic vat; nor is he enabled to ascertain the relative amounts of silver, copper, gold, and other substances which would be deposited by the same amount of electric current, whether obtained from a dynamo electric machine or a voltaic battery. In all cases where the electro-depositor would have to calculate the cost of depositing different metals—especially in cases outside those of his ordinary experience, and still more so in those in which high electromotive force is required, as when non-corroded anodes are employed—this deficiency of knowledge respecting chemical equivalents, and especially respecting the amounts of heat evolved and absorbed, and the corresponding quantities of electric energy consumed in electrolytic actions, would be an insuperable obstacle.

The chemical formulæ, also, of the various compounds which are used, or liable to be used, in the art of electro-deposition are almost entirely omitted, similarly with the equivalents and molecular weights of those compounds, including those of the most ordinary substances, such as oil of vitriol, blue vitriol, lime, soda, potash, silver cyanide, potassium cyanide, double chloride of ammonium and nickel, hydrochloric acid, nitric acid, &c.; ditto with regard to the commonest salts of lead, cadmium, zinc, tin, iron, copper, nickel, bismuth, antimony, gold, platinum, silver, sulphates, chlorides, nitrates, &c. Nearly the only exception to these statements is on page 483, where, in speaking of the double sulphate of nickel and ammonium, used for nickel plating, the author states:—"The double salt consists of one atom of sulphate of nickel, one atom of sulphate of ammonium, and eight of water." Had these formulæ been given, they would have assisted the practical electro-depositor in remembering more perfectly the actual chemical composition

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of the substances used in his calling; they would also have enabled him, in some cases, to ascertain the chemical equivalents of bodies by comparing the formulæ with each other and with the atomic weights of the elements.

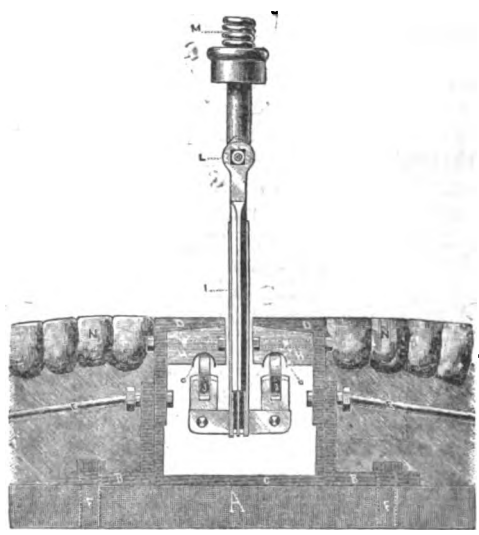
On page 214, the author very correctly remarks, that "the introduction of the electro-gilding art greatly favoured such unscrupulous persons as desired to prey upon the public by selling as gold, electro-gilt articles, which had not a fraction of the precious metal in their composition," and he mentions as an example, the manufacture of an alloy termed "mystery gold," composed of "copper 65·50, platinum 32·02, and silver 2·48;" and says, "it appears that when converted into jewellery the chief aim of the manufacturers is to defraud pawnbrokers, to whom the articles are offered in pledge, and since they readily withstand the nitric acid test the transactions are often successful." In contrast with this, we will now quote a plan recommended by himself on the immediately preceding page (p. 213). Under the heading of "gilding cheap jewellery," he says, "this class of work seldom requires more than a mere *dip* to meet the requirements of the customer; indeed, the prices obtainable for gilding articles of this character will not admit of *gilding* in the proper sense of the term." "The author has found it a very economical plan to use a *copper* anode for gilding work of this description, and by making small additions of chloride of gold when the bath exhibited signs of weakness he has been able to gild a very large number of articles, of a very fine colour, with an infinitesimal amount of the precious metal." "In his experience, although the prices were very low, the result was exceedingly profitable. Against the employment of a copper anode it has been argued that the solution must of necessity become highly impregnated with copper. To which we may reply that we did not find such to be the case in practice." In using this method, recommended by the author, his copper anode undoubtedly did dissolve in the cyanide liquid, the liquid also did become impregnated with copper, and the reason why his solution did not "become highly impregnated with copper" was that after a time the copper was deposited as an alloy with the gold upon the articles as fast as it was dissolved, and in this way produced the "very fine colour," and conduced to the "exceedingly profitable result." In proof of this explanation being the correct one, we refer the reader to page 197, where the author, in his instructions for depositing alloys of gold, and "gilding in various colours," recommends the following method for obtaining a deposit of "red gold:"—"To a solution of cyanide of gold add a small quantity of cyanide of copper solution, and increase the quantity gradually until the required tone is obtained, since an excess of the copper solution would produce a deposit of too *coppery* a hue." These recommendations are given in the same terms in the "second edition, revised and corrected," as in the first edition.

In Chapters XXIX., XXX., and XXXI., on "Electro-Metallurgy," the author has compiled, from various sources, nearly all the information at the time existing respecting the use of electrolysis in the refining of crude metals, especially copper, on a large scale; and the attempted practical application of electrolysis to the economical extraction of metals from metallic matter and from mineral sulphides in their unreduced state. The information contained in those chapters is especially interesting at the present time, in consequence of the rapid extension of the use of electrolysis on a scale of great magnitude to the refining of copper, and its adoption by most of the great copper smelters. This information, especially so far as it relates to other metals than copper, should, however, be cautiously received, because various of the processes described are in a state of trial or development, and are not yet perfected. Six pages in Chapter XXXI. are devoted to a description illustrated by sketches of Cowles's electric smelting furnace, in which, by means of the electric arc between the ends of exceedingly large rods of carbon, aided by the heat of conduction-resistance of a mixture of broken minerals, charcoal, and metals, an excessively high temperature, far exceeding that of any previous furnace, has been obtained, and the oxides of aluminium and silicon reduced to their elementary states to form alloys. But whilst this description is exceedingly interesting, it is a question as to how far the action which takes place in this furnace is really electrolytic, and how far it is merely chemical; the process also, even now, is not completely developed.

Seeing that the book contains so large an amount of workshop information, its title might well have been "Manipulations in Electro-plating, &c." The author has substantially attained his "desire to furnish a comprehensive treatise, embodying all the practical processes and improvements in the art of electro-deposition;" but in consequence of the serious omission of some of the most fundamental principles of the subject, we do not think that he has fully accomplished his object, "to treat the more scientific portion of the work in such a manner that those who are not deeply versed in science may readily comprehend the chemical and electrical principles of electrolysis." Notwithstanding its deficiencies, redundancies, &c., the book will prove of considerable value to electro-platers, jewellers and others, and will be especially welcomed by ordinary working electro-platers.

THE "BIDWELL" ELECTRIC RAILWAY CONDUIT.

It is obvious that the problem of providing mechanical and structural devices for taking off current from a conductor laid in a channel along a tram or railway line is one which admits of an immense number of solutions, and it is probable that every electrical engineer who has to turn his attention in this direction will work out the detail in his own way. At the same time, it cannot be said that the problem of properly protecting a bare wire laid in an open channel along the street is altogether an easy one, nor is it probable that any system at present in operation has yet arrived at the stage of finality. At Blackpool, for instance, on Mr. Holroyd Smith's system, very considerable difficulty has been experienced this summer from the expansion of the conductor, owing to the excessive heat, so much so that recently for several days horse-traction had to be resumed. This difficulty is one, however, which should admit of being easily overcome, and ought, indeed, to have been adequately provided for in the first design.



The Bidwell Electric Railway Conduit.—Transverse Section.

A more serious difficulty is met with in ensuring the complete insulation of the conductor and its protection from mechanical injury or from wilful interference. The former object is, of course, of the highest importance, especially when both positive and negative conductors are enclosed in the same conduit. In our new contemporary, the *Western Electrician*, of Chicago, we find a description of a device which perhaps ensures better protection from external sources of injury than any which has yet come under our notice, and it has also the advantage of enabling the channel to be easily swept and cleared from obstruction. The following is the description given by

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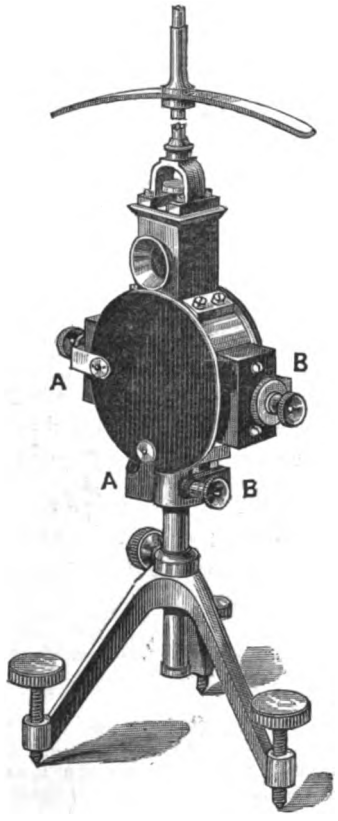
our contemporary: "The construction under this system is shown in the accompanying engraving, which represents a transverse section, and consists of the conduit placed between the rails and beneath the surface, 6in. wide and 8in. deep, with a slot or space five-eighths of an inch wide at the surface, running parallel with an opening into the conduit. A represents the cross tie upon which the conductor is placed, NN the pavement; B B angle braces; C lower conduit case; D D upper conduit case; E E stay rods. The electrical conductors G G are concave, and suspended under the surface plates D D, but properly insulated from them by the insulating wood H H. Thus suspended the conductors are placed in a position of perfect security from interference in any manner whatever, and thereby ensure an undisturbed and undiminished current. The electrical contact between the conductors and the motor on the car is made by means of the arm I, supported by the adjusting spring M, which sets in a case in the bottom frame of the car. The arm projects down through the slot into the conduit, and holds in place the contact wheels J J, which run in the concavity of the suspended conductors G G. The spring alluded to above, and the knuckle joint L, adjust and provide for the motion of the car, thus guaranteeing perfect and constant electrical contact without sparking. Both currents, outgoing and return, are provided for by the two conductors, and pass through the arm connection, which is so insulated that they are perfectly separated."

It will thus be seen that any accidental contact with the conductor from the surface is so far rendered impossible as to admit of the use of higher tension than has yet been attempted on lines of this class. The weakest point in the design is probably the employment of rolling contact makers through the spindles of which the current has to pass; but it will, of course, be easy to supplement them with brushes bearing either on the side of the wheels or on the conductors themselves.

NEW INTERCHANGEABLE COIL GALVANOMETER.

We herewith illustrate a new form of galvanometer recently exhibited by Messrs. Nalder Brothers and Co., at the Royal Society and elsewhere. It is specially designed for use when the work is much varied and where several galvanometers of different resistances would be otherwise required.



A New Interchangeable Coil Galvanometer.

The coils are made so that they can be taken out and replaced by others in a few seconds without displacing the magnet needles. Coils of various resistances are supplied as required. They are fixed in ebonite boxes which fit into the body of the instrument, and are secured by copper straps which fit under the terminals as shown in the figure. The lower terminals are insulated from the stand, and joined together, so that the two coils are connected by their lower straps, while their upper ones make connection with the terminals of the instrument. The coils are thus fixed and joined up at the same time without any loose wires.

The mirror is at the top, and works in the square lantern, where it is strongly damped. The fact that the centre of the coil has to accommodate the magnet alone obviates the necessity of a large opening, and allows the wire to be brought nearer to the needle. This form of construction also allows the two halves of the coil to be brought very close together. It will be seen that the stand is of the usual tripod form, but is adjustable for height, which is an obvious advantage. To save space the rod at the top, upon which the controlling magnet slides, is shown broken in the figure.

It only remains to add that in respect of workmanship and finish the instrument fully sustains the deservedly high reputation already attained by the firm of Nalder Brothers and Co. for high class work of this description.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis:—

RECHERCHES SUR LA CONDUCTIBILITE GALVANIQUE DES ELECTROLYTES.

BY SVANTÉ ARRHENIUS.

(*Continued from page 279.*)

§ 7.—Important Case of Double Decomposition.

From the simplified formula indicated above by an "α," one can at once deduce some important propositions. From (2 α), viz.:—

$$\alpha\,\delta\,(1-x)\,(n-x) = x^2\,\beta\,\gamma$$

one finds, by a discussion like that preceding prop. 24, that if one mixes two bodies A B and C D, the bodies A D and C B will also form, and that the more as $\alpha\,\delta/\beta\,\gamma$ is greater.

According to (4 α) [that is, (4) with $p=0$, $q=0$], $\frac{dx}{dn}$ is always positive, so—

(28) *The more one adds a body to a system in equilibrium, the more will the opposite bodies be formed.*

Then if the body is water, and one adds it to a salt, one has immediately the following consequences:—

(29) *Every salt dissolved in water partially splits up into acid and base. The quantity of these products of decomposition is so much more considerable as acid and base are feebler and the quantity of water greater.*

Let α and δ be the coefficients of activity of the salt and water, β and γ the same for acid and base; then in the majority of cases $\alpha\delta$ is enormously smaller than $\beta\gamma$; consequently for small values of n* (in the case of strong acids and strong bases n can without inconvenience rise as high as 10,000) we can neglect the term $\alpha\delta\ (n+1)/(\beta\gamma-\alpha\delta)$ in comparison with the radical, and so—

$$x = \sqrt{\frac{\alpha\,\delta\,n}{\beta\,\gamma-\alpha\,\delta}} \quad \ldots\ldots\ldots \quad (6)$$

If, on the contrary, n is excessively great, one gets—

$$x = 1 \quad \ldots\ldots\ldots \quad (7)$$

These two formulæ indicate that—

(30) *By moderate dilution the amount of salt decomposed is approximately proportional to the square root of the quantity of water used to dissolve it.*

(31) *A salt is completely split up if the water used to dissolve it is infinite.*

What is here said about water is evidently applicable to every other dissolving electrolyte.

On this subject (the decomposition of salts by water) one reads in the work of M. Berthelot (p. 199), "The process of decomposition by water of the salts of feeble acids is not always the same. Sometimes it increases little by little, either indefinitely with each addition of water, or tending towards a certain limit. . . . . Sometimes, on the contrary, the decomposition of a neutral salt is accomplished almost wholly by the first dose of water."

Thus, 1st. The salts of strong acids with strong bases are not decomposed. According to prop. 30 they ought to be. At the same time the example of the previous section shows that the salt $NaNO_3$ is only decomposed ·13 per cent. by 100 equivalents of water. Such quantities cannot

* n means the number of equivalents of added substance—for instance, water—for each equivalent of original substance—*c.g.*, salt.

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be observed by any thermic means (at least, that M. Berthelot employed). This is the reason for supposing that these salts are not decomposed at all. . . . . On the other hand, the salts of strong acids with feeble bases are notably decomposed by water. Ammoniacal salts behave in this manner. In M. Berthelot's work there are a crowd of examples.

2nd. Salts of feeble acids are notably decomposed. For example, ammonic borate is decomposed by 100 equivalents of water 59 6 per cent. Such quantities are well marked by thermal actions. Nevertheless, from what we have just said the decomposition ought to be illimitable. The reason why M. Berthelot in certain cases has only found a limited decomposition is probably because his thermal experiments did not permit the employment of more than 1,000 equivalents of water, and because the decomposition is from the beginning proportional to the square root of the quantity of water added (later still less); whence the first dose of water has an effect equal to that of the three following doses, &c.

3rd. As for salts which are almost wholly decomposed by the first addition of water, they are those for which $\beta\gamma$ is less than $\alpha\delta$ (alcoholates, for example). Concerning these salts we have already said enough. [Then follow a physiological application of law (29), and a reply to some feeble objections to the Williamson-Clausius hypothesis.]

§ 8.—Systems more Complex.

In general the case in which four electrolytes alone establish a chemical equilibrium is rather rare. The most frequent case is that of six or nine electrolytes acting on one another. Nevertheless, it is not difficult to establish general equations for a system of $n\nu$ electrolytes combined of ν cations and n anions. Let them be the following:—

$$\mathrm{I}_1\,\mathrm{J}_1,\ \mathrm{I}_1\,\mathrm{J}_2\ .\ .\ .\ .\ \mathrm{I}_1\,\mathrm{J}_n\ ;\ \mathrm{I}_2\,\mathrm{J}_1,\ \mathrm{I}_2\,\mathrm{J}_2\ .\ .\ .\ .\ \mathrm{I}_2\,\mathrm{J}_n\ ;\ .\ .\ .$$
$$\mathrm{I}_n\ \mathrm{J}_1\ .\ .\ .\ .\ \mathrm{I}_n\ \mathrm{J}_n\ ;$$

with the respective coefficients of activity—

$$a_{11}\,a_{12}\ .\ .\ .\ a_{1n}\ ;\ a_{21}\ .\ .\ .\ a_{2n}\ ;\ .\ .\ .\ ;\ a_{\nu 1}\ .\ .\ a_{\nu n}.$$

Moreover, let the original number of equivalents in the solution be similarly—

$$m_{11}\ .\ .\ .\ .\ m_{1n}\ ;\ .\ .\ .\ .\ ;\ m_{\nu 1}\ .\ .\ .\ .\ m_{\nu n},$$

and the extra number formed at the end of the process—

$$x_{11}\ .\ .\ .\ x_{1n}\ ;\ .\ .\ .\ .\ ;\ x_{\nu 1}\ .\ .\ .\ x_{\nu n}.$$

Further, let us call the quantity—

$$a_{ij}\,(m_{ij}+x_{ij})=r_{ij}$$

the *active mass* of the electrolyte $\mathrm{I}_i\,\mathrm{J}_j$.

Then, in the same manner as in § 6 above, we find a set of equations analogous to (1) and (2), and they take this form:—

$$r_{ij}\ .\ \sum_{i=1}^{i=\nu}\sum_{j=1}^{j=n} r_{ij} \;=\; \sum_{i=1}^{i=\nu} r_{ij}\ .\ \sum_{j=1}^{j=n} r_{ij}.$$

These equations may be written—

$$\frac{(r)}{\Sigma_{(j)}(r)}=\frac{\Sigma_{(i)}(r)}{\Sigma_{(i)}\Sigma_{(j)}(r)}=\text{constants as regards } i;$$

that is,

$$\frac{r_{1j}}{\Sigma r_{1j}}=\frac{r_{2j}}{\Sigma r_{2j}}=\ .\ .\ .=\frac{r_{\nu j}}{\Sigma r_{\nu j}},$$

which we may split up into—

$$\frac{r_{1j}}{r_{2j}}=\frac{\Sigma r_{1j}}{\Sigma r_{2j}}=\text{const.}\ ;\ \frac{r_{2j}}{r_{3j}}=\text{const.}\ ;\ .\ .\ .\ \frac{r_{(\nu-1)j}}{r_{\nu j}}=\text{const.}$$

And so finally we write down—

$$\left.\begin{array}{llll}
\dfrac{r_{11}}{r_{21}}=\dfrac{r_{12}}{r_{22}}=\dfrac{r_{13}}{r_{23}}= & .\ .\ . & \dfrac{r_{1n}}{r_{2n}} \\
\dfrac{r_{21}}{r_{31}}=\dfrac{r_{22}}{r_{32}}=\dfrac{r_{23}}{r_{33}}= & .\ .\ . & \dfrac{r_{2n}}{r_{3n}} \\
\ .\ .\ .\ .\ .\ .\ . & & \\
\ .\ .\ .\ .\ .\ .\ . & & \\
\dfrac{r_{(\nu-1)1}}{r_{\nu 1}}=\dfrac{r_{(\nu-1)2}}{r_{\nu 2}}= & .\ . & \dfrac{r_{(\nu-1)n}}{r_{\nu n}}
\end{array}\right\}\ .\ .\ .\ .\ .\ .\ .\ (\mathrm{A})$$

which are $(n-1)(\nu-1)$ independent equations.

But there are $n\nu$ unknown quantities (x_{ij}) to be determined. So it is necessary to have $n+\nu-1$ fresh equations. These are not difficult to get. We notice that the quantity present of each ion, I_i or J_j, is not altered by the reactions. Hence it follows that—

$$\Sigma_{(i}\,x_{ij}=0,\ \text{and}\ \Sigma_{(j)}\,x_{ij}=0.$$

These are $n+\nu$ fresh equations, one more than is required, but one of them is not independent.

Thus we have all the equations necessary for the solution of the problem. The general equation of the system (A) is—

$$\frac{r_{ij}}{r_{i'j}}=\frac{r_{ij'}}{r_{i'j'}},$$

or

$$r_{ij}\,r_{i'j'}=r_{i'j}\,r_{ij'}.$$

This equation contains the following proposition:—

(32) *When equilibrium is established among any number of electrolytes, the product of the active masses of two conjugate electrolytes is equal to the product of the active masses of their two opposites, just as if no other electrolytes were present.*

This extremely simple proposition contains the solution of the general problem—if one mixes a number of electrolytes together in any proportion, what reactions will occur? By a discussion similar to that preceding prop. 24, one recognises easily that—

(33) *Bodies possessing the smallest coefficients of activity are most likely to be formed at the expense of opposite bodies.*

§ 9.—Applications of the foregoing paragraph.

In practice the case which most often presents itself is that of two electrolytes, whose four ions are different, put to react on each other in a slightly active solvent (most commonly water). We will consider some important special cases.

Case 1. The two electrolytes are a very active acid, and the salt of a less active acid. Let the initial quantities be n and 1. If water were not present, the equation of equilibrium would be—

$$(n-x)(1-x)\,\alpha\delta=x^2\beta\gamma\ .\ .\ .\ .\ .\ .\ .\ .\ 2\mathrm{A}$$

But by reason of the presence of water the salts, of which the quantities will be $1-x$ and x, get into equilibrium with the water and their respective acids and bases. So minute quantities are decomposed by the water, and the quantities $1-x$ and x will be a little diminished, especially $1-x$, the salt of the less active acid. Let us write these so reduced quantities—

$$\frac{1-x}{\chi}\ \text{and}\ \frac{x}{\psi}.$$

Similarly the quantity of reacting acids $n-x$ and x will be a little increased, especially the latter. Call the actual quantities—

$$\lambda\,(n-x)\ \text{and}\ \rho x.$$

Calculation indicates that the greatest of the quantities χ and ψ, λ and ρ, does not differ appreciably from 1 unless $\alpha\delta$ is excessively great in comparison with $\beta\gamma$. So, writing $\psi\lambda/\rho\chi=\tau$, we have proved that $\tau=1$ if $\beta\gamma$ is comparable to $\alpha\delta$. If, on the other hand, $\alpha\delta/\beta\gamma$ is very big, τ will differ from unity, but still $\tau\cdot\alpha\delta/\beta\gamma$ will be enormously great, and hence in the equation—

$$(n-x)\,(1-x)\,\frac{\alpha\delta}{\beta\gamma}\,\tau=x^2$$

it is still necessary to suppose x almost equal to n or to 1, whichever is least. The rôle of the water consists in delaying the process a little, and can, from a broad point of view, be neglected. The same can be said of any other solvent of very small "active mass." We are, then, authorised to announce the following proposition:—

(34) *More active acids displace less active acids from solution of their salts.*

This is the proposition which, valid for bases also, is found in § 5 to agree so well with reality.

[To avoid the appearance of verbal obviousness in this statement, we can remember that by "more active" the author means "having a higher molecular conductivity."]

Case 2. Both electrolytes are salts very little decomposable by water. In this case the water may, of course, be neglected, and $\alpha\beta$ nearly equals $\beta\gamma$, so from the equation (2A) it is necessary that x is comparable either to $n-x$ or $1-x$. Thus a sensible partition of the bases among the acids will be effected.

(35) *If two salts, of which the four ions are different, are dissolved in water (or any other solvent), the two other salts possible will form to such degree that their amounts will be comparable to the amounts of the primitive salts, when the four salts are not notably decomposed by the solvent.*

This proposition, very often verified, expresses a general opinion accepted by chemists. (*See* Berthelot.)

Case 3. If, on the other hand, one of the four possible salts—say, that with the coefficient β—is to a high degree decomposable by the solvent (which is the case if it is composed of a feeble acid and a feeble base), but none of the others, an equilibrium will establish itself between this salt, its acid, its base, and the solvent, in such a way that only a certain fraction, $\frac{x}{\rho}$, remains as a salt in the system, of the quantity which would be found if the salt were not decomposed. (2A) takes the form—

$$(n-x)\,(1-x)\,\alpha\delta=\frac{x^2}{\rho}\,\beta\gamma.$$

So x will increase with ρ, that is to say—

(36) *In solutions of two salts, of which one is composed of strong acid and feeble base, the other of feeble acid and strong base, the strong acid unites by preference with the strong base, leaving the feeble base to the feeble acid. This latter salt is naturally in great part decomposed by the solvent.*

This proposition has been experimentally proved by M. Berthelot (p. 712).

Case 4. If two feeble acids have the same base, M. Berthelot believes he has proved that a sensible partition is effected. According to what has just been said, this ought to be a special case of 1, so that if the acids are almost equally strong a partition occurs; if, on the other hand, one of them is much the stronger, it seizes on a portion of base incomparably the larger. The work of M. Berthelot gives examples of both cases. Thus, a partition occurs between hydrocyanic and boric acids; while the phenol of the phenate of potassium is displaced by boracic acid.

(*To be continued.*)

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LEGAL INTELLIGENCE.

Edison and Swan Electric Light Company v. Shippey.

On Wednesday last Mr. Arthur Shippey appeared before Mr. Justice Kekewich, in the Chancery Division of the High Court of Justice, to ask him to reconsider his judgment in this action (which was reported in last week's *Electrician*), on the ground that since his lordship had pronounced that judgment certain facts had come to light which had materially altered the position of affairs. If he (Mr. Shippey) had known those facts at the time of the trial he would not have consented to the order being made, and he was quite sure they would have considerably modified his lordship's decision.

His LORDSHIP said that it was a matter beyond his jurisdiction to rehear a case upon which judgment had been pronounced. Mr. Shippey could, however, move for a new trial on the ground of misstatement of facts, but application must be made in that case to the Court of Appeal.

Mr. SHIPPEY then thanked his lordship, and withdrew.

COMPANIES' MEETINGS.

National Telephone Company (Limited).

The seventh annual ordinary general meeting of this Company was held at the offices, No. 11, Queen Victoria-street, on the 5th inst., under the presidency of Colonel R. Raynsford Jackson.

The SECRETARY (Mr. Wm. B. Campbell) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Our report is perhaps shorter than usual, and the necessity for dwelling at length upon it is also perhaps less pressing than on ordinary occasions. When I addressed you last year I pointed out that there had been a growth in the revenue, and that it had reached the sum of £81,500 for the year, including fee messages, and I explained to you that the fee messages formed a new and growing source of revenue. We had for that year received from £800 to £900 from that source, and now those receipts are £1,800 a year, and they are increasing month by month. The total gross revenue of the Company is now £92,337. 2s. 4d., or rather it was so on 30th June, and it is still steadily and satisfactorily increasing. As regards the trunk wires, I think it is desirable that I should call your special attention to the part of the report which refers to them. You will see that last year our mileage of trunk pole lines was 363, and now it is 643, and that our mileage of wires upon them was at that time 1,216, while it is now 1,919. This is a very important fact, because it indicates a valuable additional service given to those who are members of our local exchanges. They have the means of communication over a much wider area than before, and I am happy to say that they seem to appreciate highly the additional advantage so given to them. I may state without any reserve that it is our desire to extend that system much further. We spent over £8,000 upon it last year, and we shall in all probability expend a considerable sum this year. As I explained last year, our Yorkshire system was connected with the Lancashire and Cheshire system by an arrangement with the Lancashire and Cheshire Company. We are now contemplating no less than connecting our Yorkshire system with Birmingham, the Potteries, and the Nottingham district, so that all our English exchanges, excepting those very far north, in West Cumberland, will be in communication with each other. I need not dwell upon the advantages to the community which will be given by the extra facilities to residents in the towns scattered over our large district when they can hold conversation with each other over that extensive area at a moderate rate. The increase of revenue for the year is somewhat over £11,000, and I may mention that it would have been greater had we not felt it desirable to deal with our tariff in Glasgow. When we started our system there we bought up several rival companies with varying tariffs, and we thought about a year ago that the time had come to equalise those tariffs. In the process of equalisation as a matter of course we lost something. For the year that has just passed we received £2,200 less from our old subscribers than we should have done but for the equalisation of the tariffs, and to that extent our revenue for the year was reduced. I am, however, happy to be able to inform our subscribers and you that the gross revenue from Glasgow is about £1,800 more than it was before we made the reduction. You will see upon the reverse of the report that you will be asked to sanction the issue of £150,000 of what I will call debenture stock. I think that seeing this in the report was probably misleading to some of the shareholders as to the intention of the Directors. We have no intention of issuing any of this debenture stock excepting for the purpose of replacing debenture bonds which are now in the possession of the public to the extent of £75,000. The further issue of £75,000 of debentures will be very much delayed, and we do not see any definite period at which there will be any call for it. We have taken power to issue £150,000 when we only really require £75,000, because if ever hereafter it proves to be desirable to issue a further sum of debenture stock it will certainly be in the interest of the Company that that issue should not be second debenture stock; and it is merely to guard against a somewhat remote possibility that we are asking you for power to issue £150,000 instead of only £75,000 of debenture stock. We have no intention, however, of doing anything more than replace the debenture bonds now in the hands of the public. I do not know that it is necessary for me to detain you by dwelling on any other topic. I am happy to say that as regards our relations with all those with whom we have important business—that is, specially with the Post Office and the United Telephone Company—they are as satisfactory as hitherto, and that generally we stand on friendly terms with those who are using our system. He then concluded by formally moving the adoption of the report and accounts.

Mr. WM. ALEXANDER SMITH (a Director, of Glasgow): I have great pleasure in seconding the adoption of the report and accounts for the past year, and in doing so I can only corroborate what has been stated to you by Colonel Jackson in regard to the position of the Company. I am sure it must be a source of gratification to you all that under Colonel Jackson's guidance it has attained the position it now occupies. I will venture to refer to one or two points which I know Colonel Jackson intended to refer to, but which he has not done. I may say, without fear of contradiction, that this Company has always led the way in the adoption of every possible apparatus which would facilitate the services given to the public; and during the past year everything that can tend to increase our revenue, and to give a quicker service to our subscribers, has been adopted by the Company without loss of time. I have further to advert to the fact that during the past year, at a considerable cost, a large portion of the wires has been renewed and reconstructed, the result being, as Col. Jackson has stated, that we are now on the best possible terms with our subscribers; and in proof of the soundness of our methods of construction, I can only allude to the fact that, in a territory extending as far north as Inverness, down to as far south as Birmingham, all the snowstorms last year only cost the Company £600. I have the greatest pleasure in seconding the adoption of the report and accounts for the past year.

Mr. G. E. SMITH (Nottingham), referring to the question of way-leaves, expressed a fear that in some districts the wires had been run, and that afterwards it had been found necessary to put supports, or insulators, on the poles, and that they had been put on without the permission of the owners of the property. At St. Paul's Church, Nottingham, an old church, two insulators were put on, and three holes were made in the lead, leaving one hole. No one ever gave permission for that to be done. He thought it was very detrimental to the interests of the Company to let such a state of things as that go on. The vicar had been ill, and he had promised the revereрd gentleman to bring the matter before the Directors. He knew it was not the desire of the Chairman that that state of things should continue.

Mr. JOHN LEAKE (Manchester) asked if there would be any objection to giving the shareholders, in the profit and loss account, a division of the item "Working expenses for management, operators' wages, office salaries, and charges, £12,688," stating, for instance, the amount of the Directors' fees and the salaries separately?

The CHAIRMAN: I am obliged to Mr. Smith for the remarks he has made, and for bringing this matter prominently before us. We shall do our best to prevent any neglect or disregarding of our orders. It is our desire that our staff should treat householders and all with whom we have to deal with courtesy, and that we should not claim rights over property which we can only exercise properly, morally, and legally, with the consent of the proprietors or the occupiers; and representations shall be made to Nottingham on the subject. I trust that the particular point which Mr. Smith has referred to will be attended to at once, and that there will be no occasion for complaint again. As to the query of Mr. Leake, I beg to say that hereafter we shall have no objection to make a further subdivision of the items he referred to. He specially mentioned the Directors' fees—they are £1,000 a year. We do not wish to have any reservation, but to give all the information that is thought desirable and that is advantageous to the Company and to our shareholders to give.

The motion was then carried unanimously.

The CHAIRMAN next moved, and Mr. PETER GARNETT seconded, a resolution for the payment of a dividend at the rate of 6 per cent. per annum, less income tax, on the first preference stock for the six months ended June 30 last.

The resolution was unanimously agreed to; as was also a further motion, proposed by the CHAIRMAN, and seconded by Mr. W. W. CARGILL, for the payment of a similar dividend on the amount called up on the second preference stock.

The CHAIRMAN afterwards proposed the payment of a dividend at the rate of 4 per cent. per annum, free of income tax, on the ordinary stock for the six months ended June 30 last.

Mr. CARGILL seconded the motion, and it was carried unanimously.

The retiring Directors, Messrs. Peter Garnett, John Frederic Harrison, and Samuel Herrick Sands, were then re-elected, as were also the auditors, Messrs. Quilter, Welton and Co.

The CHAIRMAN: The next resolution I have to propose refers to the subject I dealt with when I addressed you a short while ago—that is, the debenture stock. I now move, "That the Directors be authorised to borrow, for the purposes of the Company, such sums of money as they may think proper, but so that the amount borrowed shall not at any time be greater than £150,000, and that all moneys so borrowed may be represented by debentures, debenture stock certificates or otherwise, and may be payable or redeemable in such events and secured in such manner and generally may be issued on such terms as the Directors may think fit."

Mr. GARNETT seconded the resolution, which was carried unanimously.

Mr. CARGILL said he had attended every meeting which the Company had held since its establishment, and at each meeting he had felt greater satisfaction and pleasure at the way the business was conducted. It was very satisfactory to the shareholders of this Company to find that all their telephonic system was conducted in such a way as to give satisfaction to the public and to afford a good profit to the shareholders. He thought that what the Chairman had stated as to the position and prospects of the Company was just as satisfactory as his statements had always been up to the present time. He had no doubt that the shareholders would all join him in passing a vote of thanks to Colonel Jackson

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and the Directors for the able way in which they had conducted the affairs of the Company. He then moved a resolution to that effect.

Mr. LEAKE seconded the motion, which was unanimously carried.

The CHAIRMAN, in acknowledging the compliment, said that they had had the assistance of the shareholders everywhere where the Company was working, and in many cases that assistance had been very valuable. He was much obliged to them for the compliment they had paid to the Board.

The meeting then separated.

The Edison and Swan United Electric Light Company (Limited).

The annual general meeting of the shareholders in this Company was held on the 9th inst. at the City Terminus Hotel, Cannon-street, under the presidency of Mr. J. S. Forbes.

The SECRETARY (Major Flood Page) read the notice calling the meeting. The report of the Directors was taken as read.

The CHAIRMAN, in the course of his remarks in moving the adoption of the report, said: I think the essence of what I have to say lies in the profit and loss account. That is simple enough. The chief feature about it that has to be dwelt upon is the fact that after charging the current business of the year with everything that can be fairly charged against it, and being somewhat more liberal than in former years upon the item of depreciation, the result shows a profit of £16,221, against £24 in the previous year. It is quite true that in that year, from circumstances which I had to explain at the last meeting, the profit made in the year ended June, 1885, of £12,000 had been reduced almost to *nil* last year, but it is gratifying to see that, as I have just said, £16,221 remains as the profit of the year which has just elapsed, after being liberal in the matter of depreciation and reserve. Now, I believe that that is the whole report, because when I come to deal with the substance of it it assumes the position of the paragraphs in the document itself. First of all the report tells you that the sale of lamps and the business of the Company have progressed in a satisfactory manner, that the profit I have mentioned has resulted, and that during the year the Directors have paid off certain mortgages, and have thus made the financial position so much stronger. Installation work has been more active during the past twelve months. The fact is that the electric light, for internal purposes at all events, is beginning to be appreciated more and more, and year after year the great clubs are beginning to find out that gas, though perhaps somewhat more economical in the mere payment per thousand feet, is not so economical or advantageous as the electric light, and they are rapidly transforming their system of lighting from gas to electricity. The Athenæum Club is so lighted, and we have also lighted the National Club. The banks are also finding out the same thing. They have to pay a large sum for lighting up, and they have large staffs in their employ who have to work in a vitiated atmosphere, and somehow or other humanity does hold its own against avarice in these days, and people who are employing large numbers of other people are beginning to have some regard for the health of those people; in fact, they find it pays, and the banks find that it will pay to use the electric light rather than gas. The electric light is in use at *The Times* office, and I think that gas has been almost entirely superseded by the electric light in the composing room. The light is much better to work by, and that is a fact which is being more and more discovered. It seems to me that that fact is taking root, and as we are in possession of the key of the fortress I trust in time that the large amount of capital, the not inconsiderable amount of anxiety and labour that has been thrown into this Company up to this time on the part of the Directors and of their technical advisers and officers, as well as the patience and forbearance exhibited in so large a degree by the shareholders, will meet with their fitting reward. I think we may take the balance this year as an earnest that that reward is within reach. We have not only advanced substantially in what is called material prosperity, but we have disposed of some of those doubtful points the issue of which at this time last year had not been determined. You know that we are possessors of patents, and I suppose that a large measure of our prosperity will depend on the validity of those patents. This is the second concern in which I have been engaged in which the investments have turned largely on the possession of patents—the telephone and this business of electric lighting—and I have arrived at one conclusion, that any one who stakes his money on a patent is a fool. That is a general proposition which I shall be prepared successfully to defend, if it needed defence, with the experience that we have got before us—I mean until the validity of the patent has been established. We are fortunate in our concern in one respect, that the cost of our patents for a large portion has taken the form of a contingent payment to Mr. Edison. The other portion took the form of an actual payment to another illustrious inventor. If that gentleman and his friends had been in the position Mr. Edison is in, and had only claims on the concern for contingent value after the people who had put their money into it had received a reasonable interest, the position of this Company would have been very different to what it is, and we should have been paying a large dividend. The fact is that we have been obliged to pay for the validity of those patents. We had no mean opponents. Messrs. Woodhouse and Rawson were the principal ones; but I think that they were backed up by other people as partners themselves, whose interests were much in the direction of their interests—that is to say, people who would be very glad indeed to use the Edison and Swan lamp without paying for it. There are plenty of them about. We have tried this matter, and we have succeeded as regarded the only two patents which were really tested—the Edison patent and the Cheesborough patent. We succeeded in the court of first instance, and in both cases those judgments were confirmed on appeal. Though the time for appealing to the House of Lords is not yet expired I think I am right in saying that, as far as we are at present advised, there is no probability that those particular judgments will be challenged in the House of Lords. We succeeded a day or two back in obtaining a judgment against an offender against whom we commenced an action for infringement, and he commenced one against us. We may assume, I think, that whereas this time twelve months the uncertainty attaching to the validity of these patents was such as to give some serious anxiety to the Directors, who, after all, have to take upon themselves the onus of determining whether these things are to be fought or not, the matter has been greatly altered. We are much more certain about it than we were, and my mind is pretty well at ease as to our patents. They have several years to run, and we must make hay while the sun shines. We must while they last take the full measure of these patents, as I suppose they will not be prolonged. We have a fixed policy in our minds turning upon these patents when the protection goes and as to what our position will then be; that is not a new matter for consideration in the lives of men who have lived my life and who were born long before the Reform Bill. They have had to consider the free trade question and protection in a great many forms. We have made up our minds what we are going to do, and that is as far as possible to retain in our hands the manufacture of our lamps, in order that we may secure to the public two advantages—the greatest measure of efficiency and the greatest measure of economy. It is quite obvious that the man who has to manufacture lamps from day to day, and who is always under the pressure of improvement, is the most likely to produce the most efficient lamp, and that the man who has to manufacture a million can do it cheaper than the man who has to manufacture a quarter of a million. We shall retain the manufacture of the lamp, and as time goes on diminish the price consistently with a reasonable profit on it; and at the end of the time for which the patent lasts, we shall have established such a general position, as the vendors and manufacturers of the lamp, that we shall be known as having the best trade mark and the best lamp. That is our policy, and that exhausts really the substance of the report and the substance of the accounts. I may refer, however, to one or two items in the profit and loss account. You will see that we have obtained by the sale of lamps, fittings, &c., and for work done, £65,736 this year, as against £51,998 in the preceding year. That is a substantial increase, some £14,000, and the great increase comes from the lamps. We have had rather more installations, and rather more private work. There is one item which is somewhat exceptional, royalties from Messrs. Woodhouse and Rawson. That firm were allowed by the Court to go on selling lamps under the obligation of keeping an account and paying a royalty in the event of the decision we obtained against them being confirmed. When we got the decision confirmed by the Court of Appeal they proceeded to pay up, and we have thus got out of them £4,217 in respect to the royalties payable to us during that period of about a year. But I think we have a claim against them in respect of the period anterior to this, and we have also a claim against them for the costs in which they were cast and which they have not paid. I suppose they are solvent. We did not wish to abuse our victory. That is not only ungenerous, but it is bad policy, and we shall not press them so long as we are convinced that they mean ultimately to do what is right and pay up. On the other side of the profit and loss account there is another favourable feature that I desire to draw your attention to, and that is, that whereas the stock, principally of lamps and material, carried over on the 30th June last year into the accounts of the current year amounted to £15,001, the stock carried over this year is only £12,868. Of course we are obliged to have in this business a very large number of lamps in stock. I do not know that I am competent to go into all the details in connection with this matter, but if you wish to have the details there are other gentlemen in this room who can supply them; but I may mention that there are lamps of different capacities—so many candles, so many volts—and that fact means a great many varieties of the Edison and Swan lamp, even though that lamp should be, under some general denomination, the same thing. We have also sudden orders coming in every now and then. A man wakes up to the fact that he wants 1,000 lamps, and determines that he will light his place up within a fortnight or so. He takes it as a matter of course that he can get the lamps all at once, although, as a matter of fact, they are not always there. Still, that is part of the general policy, to encourage the idea that people have only got to go to the shop and get what they want. Now, passing on to the next item, we have wages, purchases, cost of installations, &c., £37,159, against £33,430 last year; but there you see that is against the large excess on the other side—£65,736 of receipts, against £51,900. There is an increase there of £14,000, and of course that amount of property was not sold without additional cost, and "wages, purchases, and cost of installations" means the price of material, labour, and many other things for providing these lamps, and so on. Then we come to the item of salaries, Directors' fees, and all those things which excite so much attention generally, and you will be glad to hear that there has been some progress there. That item stood in the accounts last year at £10,853, whereas now it is £6,917. That is not all saving, because some portion of that diminution turns upon an alteration that has been made. The salaries of the engineer and other gentlemen are now in the installation account. Mr. Crisp reminds me that I might make a point by calling attention to the fact that the Directors this year, as in former years, have waived £1,500 of the fees to which they were entitled under the Articles of Association. I think they were wise to waive them. I do not think the Directors ought to have too much prosperity when the shareholders are not prosperous also, but perhaps some day, when you are getting large dividends, you will remember the fact that we have now in these hard times waived the amounts I have mentioned. If you do not think then that these amounts are morally due to us we shall not claim them. The item of depreciation of plant, &c., I next wish to call attention to. Last year there was £1,708, and this year it is £3,281. We found that the machinery was getting

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older, and we thought it wise to recognise that fact by increasing the amount of depreciation chargeable on that account, and accordingly £3,281 has been written off out of the profits to meet this wearing out. Then we have the Holborn Viaduct rent, &c., and the loss on removal from Benwell, £3,000. That is another thing that we met in the same way. It means early loss and early mistakes being written down now. That is part of our original sin being wiped out. These were losses incurred by bad bargains in former times, and as I have said before we have had to bottom it all and get rid of these bad things as far as possible. We have got rid of them to a certain extent, and we are writing down the loss out of profits. Interest on mortgages last year amounted to £833. We had some properties mortgaged which we have now paid off, except the mortgage on Ponder's End, which we shall pay off as soon as we can. Now, coming to the balance-sheet, that will show you that the capital remains intact. This time last year the capital amounted to £471,298, and it represents that amount now. The gallant secretary reminds me that in that amount are included the 23,564 "B" shares of £5 each, fully paid, amounting to £117,820. That represents Mr. Edison's contingent interest, and you will see that we say the "B" shares are entitled to a fourth of the profits after a cumulative preferential dividend of 7 per cent. per annum has been paid on the "A" shares, and the preferential cumulative dividend is £96,630, which is payable out of future profits. Before Mr. Edison, or the holders of those "B" shares, can touch any money you must have had your 7 per cent., and you must also have been paid this amount which has accumulated of £96,000. I have a great admiration for Mr. Edison, and I heartily wish he may very soon touch a quarter of our profits after we have paid 7 per cent and this amount of arrears. Now the next item is the sundry credit balances, and that stands at £5,799, compared with £13,350 last year, and that reduction made in amounts owing by us is very gratifying. On the other side of that account there is the reverse of the picture. The cost of patents, goodwill, preliminary outlay, loss on working, &c., as per last balance-sheet, was £305,000. That went through the process of diminution by writing off and selling plant, which realised excess in value over and above the valuation put upon it. It now stands at £298,000. That is on the first line, and underneath it is said, "further expenditure thereon £4,467," making together £302,821, less the amount realised by sale of plant, &c., leaving £300,814, plus Mr. Edison's shares £117,000. That makes up together £418,000, and that is capital not covered by really tangible assets. It is the amount you paid to found the business, for patents, for goodwill, &c. When you come to the items underneath you see that we have freehold property (less mortgages) £13,691; then installations in progress, £2,794. That means money coming into our coffers when we have finished the work. Plant and stock is an item standing at £30,045; that is the fair valuation of our stock and plant to carry on the business with. The office furniture is £1,057—there is an increase there during the year of £100. Then you see the item of debtors amounts to £12,946, as against £14,887 last year. Well, that shows that we have got our money in more closely, and these are all good debts and assets. We have cash at the bank and in hand £14,000. All those sums totalled up represent the really tangible assets, which, if sold to-morrow, would realise sovereigns and perhaps more. I think I have been a little exhaustive, but I have now said all I intended to say subject to being called upon to answer questions. I am just reminded that I ought to refer to one other matter, from which you will see how strange it is that other people's misfortunes sometimes help the interests of other people. I am reminded that the fire at Whiteley's was made much worse by reason of the gas. It is quite obvious that where a big fire does set in, particularly in such enormous premises, it is fed by gas pipes which are full of gas all over the place. That is a danger that does not attach to the electric light, at least to the same degree; and I daresay that that will be a consideration with people in time. There is a great agitation now going on about the safety of theatres, and we all know what a dreadful tragedy there was at the Paris Opera Comique. I suppose we shall see in course of time our theatres lighted by electricity. I now beg to propose the adoption of the report and accounts.

Mr. F. R. LEYLAND seconded the motion.

Mr. PRYOR wanted to know what had become of the legal expenses, which must be very large. He would also like to know why the £16,221 of profit was to be applied to the extinction of the amount standing to the debit of profit and loss, because on the face of it there seemed to be £24 to the credit of that account.

Mr. NEIL asked how long the patents had to run.

A SHAREHOLDER asked whether Swan's light was used at Whiteley's.

The SECRETARY replied that a great deal of the electric light was used there, but gas was used in the part of the premises where the fire occurred.

Mr. REW wished to know whether an action had been brought against the Company by the Anglo-American Brush Corporation.

The CHAIRMAN, in reply, said it would be observed in the balance-sheet that they spoke of cost of patents, &c., &c., and further expenditure thereon £4,467, which included the legal expenses incurred by the Company in upholding their patents, and they had from time to time dealt with that matter in a similar way, debiting capital with the legal expenses. They were capital charges. What was the cost of the patents? Some people who did not think it out would consider that it would be the amount paid to the patentee. But then if when the patentee was paid the patent was assailed, and they had to fight in order to establish its validity, the expenses so incurred had to be added to the cost of the patent. That was the view which the Directors took of the matter, and the view of the auditors—that the cost of protecting the patent was part of the cost of the patent itself. Thus it was made a capital charge. They did not know what was going to arise hereafter, and some day there might be amalgamations, and so on, and obviously to charge revenue a very heavy expense incurred solely for building up the patents would be taking money out of their pockets to-day to put it into somebody else's pocket in the future. He had known companies which were very prosperous that paid capital charges out of revenue, but that was because they did not want to excite avaricious competitors into too ready action by paying too large dividends. Poor companies could not do that. In the previous year they debited in the same way £8,104 to capital, the bulk of which also represented legal expenses a year ago. He thought they had every reason to be satisfied with the economical nature of the legal expenses considering the "lights" whom they had to employ. With regard to the question of the application of profit he had purposely proposed the report and accounts, because they had to adopt the report and accounts to confirm the fact that there was a profit. They thought they were bound by justice, and prudence also, to apply that profit to writing down the losses of previous years, rather than distribute it by way of dividends. When they took the business over it was a putting together of two concerns which had not been over wisely administered, though he would not say they were unwisely conceived. There were very great faults and bad bargains made, and now they had to write down the losses which were made in those early days. They had had in the working of the concern great losses. Three years ago they lost £28,000 on the working account. The following year, as the result of a rearrangement, that £28,000 loss was turned into a profit of £12,000, which they wrote down; the profit of £24 made last year was an amount dealing with which did not give them much trouble But now they had a substantial sum, and the question was should they pay it out. They thought it was no good starting a legal hare, and that, therefore, they had better use the amount in writing down the debit to profit and loss, instead of paying it away in dividends. That was a proceeding which came to this, that instead of taking it now they applied the money to the improvement of the property. The key of the patents had to run for six years from November next. That might be considered not a long time, but with the reputation which they had built up, and which they were building up, a good deal might be done in that time. The Edison and Swan interests were happily united in England, but they were equally unhappily disunited on the Continent, and they were cutting each other's throats in France, Belgium, Germany, and other places. They had done a great deal to induce the Edison people abroad to fall into the same happy amalgamation which they had succeeded in establishing in this country, but unfortunately so many were interested in the Edison patents abroad that it was almost impossible to say to whom the patents really belonged. With regard to the question about the Anglo-American Brush Company, they stated in their report:—"Other actions are pending in connection with the Company's patents, but in these the Directors are advised that there is no probability of the judgments of the Courts of Appeal being reversed." That meant that there were actions pending with other people. It was true that the Brush Company had commenced proceedings, having issued a writ. He did not ever undervalue an adversary, but he did not think there was much in the action that was being taken against them by the Brush Company, and Mr. Crisp, who was a very good judge, acquiesced in that opinion. That Company had got what they thought was a patent which this Company was infringing. This Company had got a patent which they knew the Brush Company were infringing, and that was the difference. Upon that ground they were inclined to stand. What the Brush Company in their wisdom would seek to do he did not know, but they on their side had no desire to embitter the controversy. As to the Electric Lighting Act, there was a tremendous kick-up about it last year when he gave his evidence before the Committee. The only concession made to the electric light companies was that they were to have possession for 42 years instead of 21 years. The thing went through Committee, and, on the recommendation of that Committee, into the House of Lords; and then the Board of Trade, who took strong views, tried to bring some clauses into it which had the effect of modifying that concession. The House of Lords would not consent to it, and the measure was withdrawn. This year Lord Thurlow, who was Chairman of the Brush Company, brought in a Bill which went to the House of Lords, and they took the essence out of it—the goodwill. It had gone down to the House of Commons with the goodwill out of it, and as their hands were full for the end of the Session he thought they were not likely to pass it.

The motion was carried unanimously.

The retiring Director (Mr. Shelford Bidwell, F.R.S.) was re-elected, as were also the auditors (Messrs. Quilter, Welton and Co.).

A vote of thanks to the Chairman was then passed unanimously.

The CHAIRMAN, in reply, said it was very gratifying to the Directors to find that after many years of great anxiety they were enabled to present a substantial, and, in their opinion, satisfactory statement of accounts. He thought that their future was an assured and good one, but he hoped they would not reproach him if a few years hence that opinion should be proved to be too sanguine. It was his opinion, and he believed it was shared by his colleagues.

The proceedings then terminated.

CITY NOTES, &c.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of July were £23,400; from 1st January to 31st July, they amounted to £150,520; while for the corresponding months of 1886 and 1885, they amounted to £147,560 and £168,040 respectively.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended August 5th, were £2,791, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

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COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug 10.		Business Done Week Ending Aug. 10. Highest.		Lowest.	
Anglo-American	36½,	37½	36		—	xd
Do. Preferred	59,	60	60		—	xd
Do. Deferred	14½,	15½	—		—	
Brazilian Submarine	11⅝,	11¾	11½		11½	
Cuba	12,	12½	12⅝		12	xd
Do. Preference	18,	19	18		—	xd
Direct Spanish	2⅞,	3	—		—	
Do. Preference	7½,	8½	—		—	
Direct United States Cable	8⅞,	9	—		—	
Eastern Telegraph	11,	11½	11 3-16		11	xd
Do. 6 per Cent. Preference	14,	14½	14		—	xd
Do. 5 per Cent. Debentures, 1899	105,	108	107		106	
Eastern Extension	11¾,	12	11 15-16		1	⅝
German Union	10½,	11	10¾		--	
Globe Telegraph and Trust	5½,	5½	5½		5½	
Do. Preference	13⅜,	13⅝	13⅝		13	
Great Northern	13½,	14	13⅞		13½	
Indo-European	35,	37	—		—	
Reuter's	7½,	7¾	—		—	
Submarine	175,	185	—		—	xd
West India and Panama	⅝,	¾	—		—	
Do. 1st Preference	9,	9½	9½		9½	
Western Brazilian	8,	8½	8½		—	
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	104,	107	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	11-16		—	
Oriental	½,	⅝	½		—	
United Telephone	11½,	12	12½		11⅞	
United River Plate	4¾,	5¼	—		—	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—		—	
Do. (fully paid)	3,	4	—		—	
Swan	1½,	1½	—		—	
Maxim Weston	½,	¼	—		—	

MISCELLANEOUS.

Telegraph Construction	35½,	36½	36½		35⅝	
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	22⅞		22½	xd

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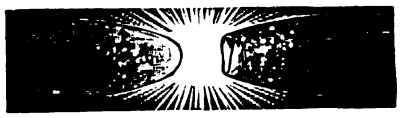
GLOBE  BRAND.

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NOTES.

TRAIN LIGHTING.—The Great Northern Railway are providing electric light in some of their carriages, we believe, by means of accumulators.

CLUB LIGHTING.—The committee of the Carlton Club have decided upon lighting throughout with electric light. The work has been entrusted to Messrs. Thompson and Ritchie.

PROJECTED FRENCH CABLES.—A project has been submitted to the Committee of the French Chamber who have charge of the Budget for 1888, providing for the laying of submarine cables between the east coast of Africa and the Islands of Madagascar and Réunion.

THE CHINESE TELEGRAPHS.—It is stated that the Chinese Telegraph Companies and the Chinese Administration have effected an agreement, to which the Russian Administration is also a party, by which communication is to be established with the Siberian land lines, and a tariff established which is not to compete with the cable companies.

SURGICAL ELECTRICITY.—We understand that the so-called "galvano-cautery" batteries used in connection with the recent operations on the throat of H.I.H. the Crown Prince of Germany by Dr. Morell Mackenzie, were designed by Mr. Thistleton, of Old Quebec-street, W., and contained several simple but substantial improvements.

PHYSICAL CONSTANTS.—The French Société de Physique has undertaken the publication of a complete list of physical constants, according to the results of the best determinations, and has appointed a committee consisting of the following members to undertake the task:—MM. Joubert, Cailletel, Dufet, Lippmann, Romilly, and Violle. The result should be a work of considerable value.

ROBERT STEVENSON'S LIFE OF FLEEMING JENKIN.—We understand that the forthcoming memoir of the late Prof. Fleeming Jenkin will be supplemented by two volumes of Mr. Jenkin's essays and reviews, which have been arranged for publication by Mr. Sidney Colvin and Prof. Ewing, and will contain, amongst other interesting matter, essays on submarine telegraphy, telpherage, and the application of graphic methods. The work will be published some weeks hence by Messrs. Longman.

TYNEMOUTH.—At the last meeting of the Tynemouth Town Council a motion was brought forward and seconded, to the effect that the Town Clerk be instructed to apply to the Local Government Board for sanction to light the new market by the electric light, and to refer the question of obtaining a license to the Trade and Commerce Committee. Against this an amendment was moved, that the electric light be abandoned. On a division, nine voted for and six against the motion, which was consequently carried.

DUNSTABLE.—AMERICAN COMPETITION.—At a recent meeting of the Dunstable Town Council a communication was read from the American Electric Manufacturing Company, stating that their foreign agent, Mr. C. R. Heep, was at present in America, but on his return would at once call upon the Council, if they would leave the matter open. The company expressed their belief that they would be able to give the corporation every satisfaction. The Mayor remarked that if it only had the effect of reducing the price of gas that would be something.

THE RECORDED DEVELOPMENT OF ELECTRICITY IN THE NICE EARTHQUAKE.—The Biological Society of Paris had before them at a recent meeting the case of the telegraph operator who received a powerful electric shock at the moment of one of the earthquake shocks at Nice, which was mentioned in our columns at the time. It appears that the unfortunate man has suffered from partial paralysis in the hand through which the shock was received from the telegraph line. The doctors appear to entertain no doubt that the occurrence was due to a powerful discharge of electricity.

THE CRISIS IN THE AMERICAN CARBON TRADE.—It appears that the intention of the Mutual Carbon Manufacturing Association will not be affected by the break up of the Cleveland ring, and in a circular issued to the local electric lighting companies it is stated that the association has already secured contracts for the supply of 12,000,000 carbons per annum. Efforts are being made to increase this figure to 20,000,000. From some correspondence in the columns of our contemporary, the *Electrical World* of New York, it appears that several firms are disputing the honour of having been the first to back out of the combination.

MAURITIUS.—One result of the recent difficulty in Mauritius will probably be the connecting of the island with Europe by telegraph. For several years this step has been pressed on the attention of the Colonial Office, and its importance has been acknowledged on all hands. Still nothing was done; but during the last twelve months, owing to the isolation of Mauritius, difficulties have arisen and mistakes have been made which might have been avoided had there been an opportunity for ascertaining the views of the Colonial Office. At present telegrams have to be sent to Natal by steamer and are then despatched from Durban, a delay of a month being frequently the consequence.

THE USE OF PERMANGANIC ACID IN SECONDARY BATTERIES.—According to M. Meserole a trace of sulphate of manganese, added to the dilute sulphuric acid in secondary batteries, appears to assist the forming process considerably, especially in batteries of the Planté type. The quantity of manganese should not exceed one thousandth part of the electrolyte, otherwise a precipitate is formed. The presence of manganese in small quantity appears to cause the formation of permanganic acid while the cell is being charged. When the cell is fully charged the characteristic red colour of the acid solution is very apparent, and it is probable that the advantage of its presence results from the oxidation of any sulphate of lead which may be formed on the plates.

TUNSTALL.—A local paper says:—"For four nights last week the inhabitants of Tunstall had an opportunity of seeing the application of the electric light to the purposes of street lighting, Bank-street being lit up with incandescent lamps. A lamp of 17 candle-power was placed in each of the ordinary lamp-posts, and a group of three on the lamp-post abutting on the main street. The light from these three was more powerful than the treble burners with which the street is ordinarily lighted. Parsonage-street, which is about 300 yards long, had perhaps more light than is required for a bye street, and this was supplied by two arc lamps. The whole work was executed by Mr. W. O. Rooper, of Stafford. The light was inspected during the week by the members of the local board."

ELECTRIC GOVERNORS.—M. E. Menges has brought out a device for obtaining the automatic regulation of shunt or series-wound dynamos by means of a solenoid placed either in series or shunt upon the main circuit, and which acts directly upon the throttle valves of the gas or steam engine. It is difficult to discover from the description before us any specially novel

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feature in this arrangement; in fact, the idea appears to have been put into operation in a somewhat crude form. Our French contemporaries, who are apparently under the impression that this is the only electrical governor in existence, have evidently never heard of Richardson's or of Willans'. M. Menges' invention has therefore produced a thrill of admiration which must be highly gratifying to the distinguished inventor.

THE TELEPHONE IN AUSTRALIA.—The Government in New South Wales has for some time past utilised the telephone as a means of communication between outlying districts, where telegraphic business is not sufficient to engage the whole attention of an operator. The innovation has worked so well that at the present time there are no less than forty telephone stations in New South Wales. In only two instances, however, has the postal department of Victoria employed the telephone in this manner, and even in these cases, it has only been with the object of permitting communication to be maintained with the lighthouse keepers at Point Lonsdale and Cape Nelson. The example of New South Wales, however, is likely to be followed in the future, as several deputations have been promised telephonic communication with stations which cannot now be reached by telegrams.

THE TELAUTOGRAPH.—According to a Paris telegram the writing telegraph, to which the name of Telautograph has been assigned, has been exhibited in that city. It is a little doubtful whether this information is strictly correct, not because writing telegraphs are anything new (Bain's chemical telegraph and Cowper's ingenious apparatus are well known to electricians), but simply because the term "telautograph" has been appropriated by Elisha Gray for an instrument of this description which, according to the latest information from the States, he is still engaged in perfecting. There is, however, already in operation an American Company which makes use of an instrument essentially similar to Cowper's, and this is probably the apparatus exhibited in Paris. In this apparatus the resistance is varied by means of the compression of carbon plates, instead of resistance coils as in Cowper's telegraph.

MAGNUS VOLK'S RAILWAY.—In the House of Commons on Tuesday last Mr. Picton asked the Chancellor of the Exchequer whether he would be good enough to state on what statute or on what authority the exemption from passenger duty of railways on public roads, as in the case of Volk's Brighton Electric Railway, is dependent.—The Chancellor of the Exchequer said that that was not exactly a case of exemption. Volk's Brighton Electric Railway did not fall within the legal definition of a railway, and was not subject to passenger duty. It, however, paid duty in another form, for by a clause in the Customs and Inland Revenue Act of 1883 any vehicle drawn or propelled on a road or tramway by steam or electricity was subject to carriage duty. In reply to a further question the right hon. gentleman said that the words he had quoted confirmed the view that tramways were not liable as railways to passenger duty.

ANNUAL OUTING.—The annual outing of the electrical and engineering staff of the Royal Courts of Justice took place on Monday, the 15th inst., when they proceeded to Egham. Amongst the guests were Mr. A. Grundy, of Baily and Grundy (late electrician at the Courts), Mr. Martin Madders, engineer of the Orange-street Waterworks, Mr. Shurman, engineer to the Law Land Company, and others. On arrival at Egham, a scratch match of cricket was arranged, the result being that Mr. Bamford's eleven beat Mr. Miller's eleven by seven wickets. At the dinner, which was served at the Barley Mow, Mr. Grundy, in the unavoidable absence of Mr. Palfreeman, the chief engineer, took the chair. The toasts of "The Queen," "The Law Courts Staff," "The Chief Engineer," "The Ladies," "The Stewards," "The Visitors," were enthusiastically drunk, after which the party adjourned to the river, where several interesting rowing matches were decided. The party returned to town by a late train, a most enjoyable day having been spent by all.

TELEGRAPH RATES.—In the House of Commons on Friday last Mr. Sinclair asked the Postmaster-General if, considering the facilities afforded to the press for the transmission of long telegrams, he was prepared to make any concession to individuals and private firms desirous of sending telegrams of considerably more than the average length; and if he could see his way, with a view alike to promote the interests of the public and the financial prosperity of the Post Office, to reduce the charge for such telegraphic messages as exceeded twenty-four words to one shilling for the first twenty-four words (the present charge for a message of this length), and a further charge of one penny for each additional four words after the first twenty-four?—Mr. Raikes said that after the fullest consideration he had concluded that it would be undesirable to make any alteration in the tariff of telegraphic messages, so short a period having elapsed since the recent reductions. The experiment could not be made, at any rate, until the financial results of the recent reductions in the price of messages were fully ascertained.

THE OERLIKON DYNAMO.—Mr. B. H. Thwaite writes us from Liverpool as follows:—"That there is no danger of overheating in the working of the Oerlikon dynamo is absolutely proved by those at work in the electro-metallurgical establishment near Turin. In these works there are five Oerlikon dynamos, each working with their full charge (50,000 watts) day and night, with only an intermission of five minutes in the twenty-four hours, without heating. This is the only dynamo tried for the electro-metallurgical (copper) process that would do this, although the best dynamo (I believe from Berlin) had been used." In the article on the Oerlikon dynamo in our last issue we credited the machine with having performed a run of fourteen hours with a rise of temperature of 60°C. in the armature and 35°C. in the field. Mr. Thwaite now writes to substantiate a much more remarkable performance, and we can well believe that, as he says, no other machine from Berlin succeeded in developing 50,000 watts for twenty-four hours "without heating" (words which he underscores twice). It seems to us, however, that our own account is better calculated to inspire confidence in the merit of the design than any such phenomenal result as described above.

THE THUNDERSTORMS.—On Tuesday and Wednesday last severe thunderstorms took place in all parts of the country, and several fatal accidents are reported. In London a man who had taken refuge under a tree in Maida Vale was killed, another man was killed on Carlton Bridge, Harrow-road, and a third who had sought shelter under a tree in Portsdown-road was also killed. Several people in this neighbourhood are also reported to have been knocked down and rendered insensible. In Birmingham district three men were killed, and considerable damage was done to property. In London several trees and buildings in Highbury and Canonbury were struck, and we also hear of a similar case in Cannon-street, though it appears that not much damage was done. About half-past eight a remarkable flash was witnessed in the neighbourhoods of Lambeth and Westminster, where a narrow

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line of forked lightning is described as having suddenly broken up into thousands of balls, like the discharge of a skyrocket. Although accompanied by torrents of rain, the storm was remarkable for the absence of wind and the consequent slowness with which it travelled. In the west of London the storm began at five o'clock, and lasted nearly four hours, passing away towards the south-west. A print from a negative taken during Wednesday night's storm by an amateur who occupied a good position for view at Earl's-court, is described as showing a flash of forked lightning in the act of *rising* from the ground, with a somewhat faint flash of a return spark travelling downwards.

BRADFORD, YORKS.—At a recent meeting of the Gas Committee of the Town Council, Mr. Lobley asked what steps had been taken by the committee with regard to the furtherance of electric lighting. He put the question because he was a member of the Markets and Fairs Committee, and they had had several applications in reference to supplying electric light to the market property.—Mr. Alderman Priestman said that the committee had collected much information respecting the electric light, and he had hoped before now to have come to the council with a proposition for spending a sum of money to place down an extensive installation before the coming winter. Owing, however, to the immense amount of work which had been placed upon the town clerk and his office in consequence of the Jubilee celebrations they had not been able to get along with the work so fast as they would have liked to do. The work was again proceeding; but, seeing that summer had so far advanced, it was quite impossible to complete it before winter. On the whole it did not seem worth while to spend the money just now, because the interest upon the amount of money expended in the meantime would be lost. In all probability there would be improvements in electric lighting, and this would enable them to get a more perfect system by waiting than they could at present obtain.

TENDERS FOR STREET FIRE ALARMS AND TELEPHONE COMMUNICATION AT HORNSEY.—The Hornsey Local Board have received the following tenders for street fire alarms and electric communication throughout their district, the amounts being for Section A, Section B, and for maintenance per annum, respectively:—Radcliffe, Birmingham, £927, £458, £100; Jennings, Lambeth, £760, £609, £35; Stuart, Twickenham, £829, £492, £75; Siemens, Westminster, £800, £500; Sax, Bloomsbury, £755, £362, £80; Telegraph Manufacturing Company, £725, £362, £100 to £120; Blackburn, Nottingham, £660, £340; Reid Bros., Wharf-road, N., £702, £290; Sharples, Preston, £649, £340, £90; Nelson, Leeds, £616, £356, £60; Theiler, Canonbury, £640, £300, £120; Eidsforth and Mudford, Holloway, £577, £320, £42; India Rubber Company, Silvertown, £550, £260, £86; Fowler, Lancaster and Co., Birmingham, £389, £205; Robertson and Sunderland, Halifax, £393, £170; Blenheim, Egham, £276, £144, £10 (accepted). The Exchange Telegraph Company tendered only for Section B, £376, and maintenance £36. Durham, Stockport, for fixing telephone only, £500. It will be seen that for the A district the highest and lowest tenders were £927 and £276 respectively, for the B district £609 and £144, and for maintenance £120 and £10 respectively.

THE ELECTRIC MOTORS OF THE THOMSON-HOUSTON COMPANY.—The Thomson-Houston Company have for some time past been giving their attention to the construction of electric motors as well as to the development of an electric railway system. It does not appear that they have succeeded in adapting their remarkable method of dynamo construction to the requirements of electric traction, and for this purpose they have now brought out a much more commonplace looking machine. The new motor consists of a pair of upright cylindrical field-magnets, with substantial pole-pieces at the top, and a drum armature with a special winding, the yoke-piece being merged in the bed plate. The machines are shunt-wound, and upon constant potential circuits they are said to be practically self-regulating under all loads, while the brushes do not require adjustment, and no sparking is observable. A commercial efficiency of over 90 per cent. is claimed. Great care has evidently been taken in the mechanical construction of these machines. The base is heavy and the standards which support the bearings for the armature shaft are very strong and stiff. This is all the more essential owing to the position of the armature above the field, but it necessarily results in a somewhat heavy machine; indeed, although we have not as yet obtained the figures, yet we have no doubt whatever that as regards weight per horse-power the construction cannot in this respect compare favourably with motors of English design.

AN ELECTRIC FREIGHT RAILROAD.—The ease and slight expense at which an electric railroad can be operated in large works already provided with a dynamo for electric lighting is well shown, says the *Electrical World*, in the venture recently carried out by the East Boston Sugar Refinery at East Boston. This refinery, which is the largest in New England, is situated about 1,300ft. from the docks where the raw sugar is unloaded from the ships. Formerly the hogsheads and bags were loaded on a railroad truck drawn by horses, the work being such as to tax the animals very severely and necessitating frequent changes. As the refinery is provided with a 150-light Edison plant, it was determined to put in an electric railroad, and the installation was undertaken by the Sprague Electric Railway Motor Company of New York. The rolling stock consists of two flat cars, one of which carries the motor of fifteen horse-power at its forward end, together with a raised platform, upon which are placed the regulating and reversing switches. The cars are capable of taking a load of 12 hogsheads, equivalent to 30,000lb. The current is taken from the lighting dynamo and led to the motor from an overhead wire and trolley, the track being used on return. With the electric railroad the work of transferring can be done in one-fourth the time formerly required with horses; and although ships are constantly unloading at the docks the limiting capacity of the railroad to handle the work has not yet been reached. The motor operates without noise, and although the track is always in bad condition, being invariably covered with sugar and molasses, no difficulty in operation has yet been experienced. Another interesting feature is the fact that thus far no appreciable increase in coal consumption due to the operation of the electric railroad in connection with the lights has been noticed.

SUGGESTED EXPLANATION OF THE VARIATIONS IN TERRESTRIAL MAGNETISM.—In another note we give a brief account of the important researches on the discharge of electricity through gases which has recently been communicated to the Royal Society by Prof. Schuster. The paper contains also a remarkable application of the results to the explanation of the cause of the diurnal variations in terrestrial magnetism. Prof. Balfour Stuart had already suggested that in the upper regions of the atmosphere the air currents may, owing to the lines of force of terrestrial magnetism, have electric currents circulating in them. This suggestion has received some support from mathematical considerations, which seem to indicate that the cause of the variations is to be found in the upper regions of the atmosphere;

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but the difficulty has been to account for the starting of such currents, which would require an E.M.F. far exceeding anything which can be assumed to exist ("which could possibly exist," says Prof. Schuster) in the atmosphere at these heights. "But," he continues, "as there are very likely continuous electric disturbances going on, such as we observe in auroræ and thunderstorms, the regions within which these discharges take place would act as conductors for any additional electromotive force, however small, so that any regular motion, such as tidal motions, could very well produce periodic effects affecting our magnetic needles. If these original discharges increase in importance, then, according to the results obtained in this paper, the currents due to the smaller periodic causes would increase also, and they may increase in a very rapid ratio. We know that the electric discharges in the upper regions of the atmosphere are considerably stronger at times of many sunspots, and this may account for the fact that at those times the amplitude of the daily oscillation of the magnetic needle is considerably increased."

Long Distance Telephony.—In the House of Commons on Tuesday last Mr. Jacob Bright asked the Postmaster-General if he was aware that there was communication by telephone between Hamburg and Berlin, between Rouen and Paris, and between towns widely distant from each other in the United States; whether his department had from time to time received representations from Manchester in favour of telephonic communication between Manchester and London; and whether he would take steps that what was done in other countries might also be done in England, to the advantage of the commerce of the country.—Mr. Raikes: I have been informed that telephonic communication has been established between Hamburg and Berlin, Paris and Rouen, and between other towns on the Continent of Europe, and also in America. The Post Office has not received representations from Manchester in favour of telephonic communication between that town and London. The United Telephone Company recently asked the terms upon which the department would provide telephone wires between London and Manchester, but up to the present time I have received no answer to the letter which I have caused to be addressed to them on the subject. Having regard to the cheap and swift means of communication which at present exist by means of the telegraph between the principal towns in the United Kingdom, I am inclined to think that it is extremely doubtful whether there would be much public advantage in establishing telephonic communication generally between those towns.—Mr. Jacob Bright: Would the right hon. gentlemen say whether it is practicable to have telephonic communication between Manchester and London, and whether there would be any difficulty in establishing such communication?—Mr. Raikes: I am advised that it is practicable to do so, but there would be considerable expense in procuring new way-leaves, as the poles at present in use could not be made available for telephonic purposes. The machinery would be expensive, but, subject to that, I believe there is no practical impossibility.

"Experiments on the Discharge of Electricity through Gases."—In the number of the *Proceedings* of the Royal Society which has just appeared there will be found a paper by Prof. Schuster, F.R.S., containing an important contribution to our knowledge of the phenomena of the discharge of electricity through gases. The principal result established by these researches is the following:—"A steady current of electricity can be obtained in air from electrodes at the ordinary temperature which are at a difference of potential of one-quarter of a volt only (and probably less); provided that an independent current is maintained in the same closed vessel." In other words, while a continuous discharge is passing through a vacuum tube the gas acquires the property of conducting crossways under an E.M.F., which, says the author, "I believe to be indefinitely small, but which the sensitiveness of the galvanometer I was using has prevented me from tracing with certainty below a quarter of a volt." He then shows that this leads to the important conclusion that "there cannot be a finite difference of potential between a gas and a metal in contact greater than that amount." This conclusion has generally been tacitly assumed in discussions of contact potential, and it is therefore the more satisfactory to obtain an experimental proof of its correctness. Prof. Schuster accounts for the observed facts upon the following theory:—"If the two atoms of a gas making up the molecule are charged by opposite electricities, but are held together in addition by molecular forces, a finite force is required to overcome the latter. But as soon as that force is overcome and the atoms themselves are set free to diffuse and constitute a current, these atoms will be able to follow any electromotive force which we may apply. If, then, we have auxiliary electrodes, these electrodes will establish their electric field, which we can never screen off completely from any other part of the vessel except by closed surfaces. The atoms, with their positive and negative charges, will diffuse across to the auxiliary electrodes and give off their electricity to them. No finite difference of potential is required in the auxiliary electrodes, because even if there is work done in making an atom interchange its positive for negative electricity, that work is undone again at the other pole, where atoms of a similar kind interchange negative for positive electricity."

The Technical Education Bill.—Prof. Silvanus Thompson, in *The Times* of Monday last, expresses the profound distrust with which technological teachers regard that provision of the Bill now before Parliament which practically puts all the control of technical education in the hands of South Kensington. In the course of his letter Prof. Thompson says:—"I happen, Sir, to know something of the working of the Science and Art Department, having at one time come into relation with it as a student, at another time as a teacher, and in each case have been driven by its redtapism to dispense with the aids which its organisations offered. My own fees at the Normal School of Science I paid rather than enter as a free student under the impracticable conditions that environed the studentship awarded to me. I have long ceased to teach under the conditions imposed by the department—conditions which tend to sterilise and fossilise all good work. It would be quite impossible to carry on much of the present work of the City and Guilds' Technical College here at Finsbury if the arbitrary rules and regulations of the Science and Art Department were to be imposed upon us. The rules of the Science Directory, for example, would entirely preclude a grant being earned on any one of our students in practical chemistry, because our laboratories, which we believe to be not only more modern but better than those prescribed by the rules of the Science and Art Department, do not accord with the stereotyped prescriptions issued from South Kensington. To put our chemical classes under the rules of the Science and Art Department would simply ruin them. If I turn to the branch of science that is my own pursuit, physics, I find that it is, by the inexorable rules of the Science and Art Department, cut up arbitrarily into two 'subjects'—(1), heat, sound, and light; and (2) electricity and magnetism. If I get together, say, a class of apprentices from the optical workshops of London, and teach

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them optics, or if I get a class of young engineers and teach them heat, then by the rules of the Science and Art Department this is not technical education at all; there is no grant for such teaching. If I teach the opticians what they do not want, heat and acoustics, as well as their optics, then I am giving them technical instruction. Or I may teach them building construction, or geology, or zoology, or naval architecture (not that I know anything of these branches of science) and I am equally giving them technical instruction, for these are subjects 'prescribed' as such by the Science and Art Department; but directly I settle down to teach these apprentices the optics that they want to know—the one subject that is technical to their industry—I am no longer giving technical instruction as defined by this Bill."

TRAIN TELEGRAPHY.—"Telegraphing to and from a moving train, for which the above seems to be the best short title, is getting (says the American *Railroad Gazette*) to be an old story on the Lehigh Valley Road, the operators of the Consolidated Railway Telegraph Company having travelled on three trains each way daily between Perth Junction and Easton now for some months. Several modifications and improvements have been made in the apparatus and plant (if a thing of which there is so little may be dignified by the word "plant"), and the facility with which the work is now carried on is such as to give added promise of the useful career in store for this invention. It was very soon discovered when the original apparatus was tried that the distance at which a current could be induced was not by any means so limited as had been anticipated, and that ordinary line wires could be successfully used. In practice it is found, however, that a separate line is more satisfactory, for the reason that most of the ordinary lines of poles make occasional detours into swamps, over mountains, &c., and thus interrupt the operators, though the trouble from undesired currents from other wires on the same poles is found to be hardly worth noticing, "quantity" currents having little or no effect upon the "intensity" currents used in the train system. A pole line is preferable to a wire laid along the rails, for the reason that it makes so much less work for the line inspector. A well built pole line on short poles (about as high as a car roof) is cheap and durable, and requires comparatively little attention from an inspector, while tracks must of necessity be constantly tampered with by repairers, and thus keep the wire inspector always on the go. A pole line is especially desirable on a new road, for it can be duplexed and used for ordinary business from office to office, thus in most cases providing for the whole business of the company and the towns on its line by a single wire; and an aerial line, as is well known, has great advantages over one on or under the ground in its freedom from retardation by the earth. The metallic roof of a car and the truss rods on the under side thereof have been connected with each other and successfully used as the induction coil, so that it seems quite likely that the convolutions of wire can be dispensed with. The company now use a telephone receiver at both ends, the vibrator of the sending instrument sending the currents so that the buzzing, which sounds like that of a very shrill bee, is exactly reproduced in dots and dashes in the telephone. To read these dots and dashes is like reading Morse characters made by a steam whistle, which to most operators is not so pleasant as the familiar sounder; but the train operators find no difficulty in it, nor are they disturbed by the noise of the train, even with the windows open. Already the Lehigh Valley has experienced the value of the service in some typical cases, one of which was that of a breakage in the engine, which delayed a train some five miles from a telegraph office, and which under ordinary circumstances would have necessitated a waggon or foot trip that distance, but which by the aid of the apparatus on the train was settled at once, a relief engine being sent for and brought to the aid of the train in about ten minutes."

THE MELTING PLATINUM STANDARD OF LIGHT.—M. Violle, in a statement which he has recently submitted to the Académie des Sciences, deals with the comparative radiations from melting platinum and melting silver. One of the metals was introduced into the little decimal lamp of Dr. Siemens, which consists essentially of a box pierced with a hole one-tenth of a square centimetre in area. Immediately behind this hole is the metal in the form of a thin ribbon traversed by a strong current of electricity, which is raised in intensity until the point of fusion of the metal is reached, when its radiant power can be observed. In this way M. Violle found that the total radiation from melting platinum is 54 times that of melting silver. This ratio of total radiant energies, while very considerably on the side of the platinum, is yet much lower than the ratio when luminous radiations only are compared, in which case it is as much as 1,000 to 1. In the course of his observations, M. Violle admits that Mr. Methven is correct in stating that in all flames there is a region of constant radiant intensity. For his own experiments upon the comparative luminosity of the radiations from molten silver and molten platinum, M. Violle employed, as an intermediary, the Hefner-Alteneck amyl-acetate lamp, and which, according to his determination, is related to the other photometrical standards by the ratio as follows:—1 Siemens = 1·95 Hefner = 0·832 Methven = 0·208 Carcel = 0·1 Violle. Thus the radiation of light from a square centimetre of molten silver is less than 0·02 Hefner-Alteneck. Mr. W. J. Dibdin, in his report on photometry to the Metropolitan Board of Works, to which we referred last week, gives the following description of his method of working with the platinum standard:—"Unfortunately I have been unable to try the precise plan suggested by M. Violle for obtaining a standard from platinum at its melting temperature; but in lieu of this I have tried a device which gives promise of practical results. The method adopted was to heat to its melting point, by means of an oxy-hydrogen flame, a piece of platinum foil placed behind a steatite screen perforated with an aperture smaller than the portion of platinum actually incandescent. This arrangement, while simple in operation, has afforded very promising indications, and seems well worthy of further experimental observation, as there can be little doubt but that an easily worked and reliable system for obtaining a steady light from molten platinum would find ready acceptance as being definite for all time. When working by this method, the oxy-hydrogen flame is gradually increased in intensity until the platinum foil melts. When this happens the oxygen is turned off, and a fresh portion of foil, which is carried on two rollers, one on each side of the aperture, is brought into position, and a second experiment made; and thus successive readings obtained, if necessary, in rapid succession. The foil is wider than the portion actually perforated by the intense heat, so that by turning a winch-handle, a fresh surface is almost instantly obtained. The operations involved in testing are thus about a quarter of a turn of the winch-handle, and turning the oxygen on and off at the beginning and end of each test respectively. The aperture in the steatite screen is about one-fifth of an inch in diameter, and allows light equal to a little more than two candles to pass to the photometer disc. While the proposition to obtain a standard light by this means is theoretically satisfactory, and the preliminary practical results have been very promising, the details are as yet insufficiently worked out to compete against more established systems."

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THE RISE AND PROGRESS OF TELEPHONY IN THE UNITED KINGDOM.

(Continued from page 289.)

Now that the practical success of telephony had been assured it became the duty of the Crown to consider the position of the companies in respect of the monopoly of telegraphic communication which it had acquired in virtue of the Telegraph Act of 1868; the result being that an action was entered against the Edison Company just previous to the amalgamation, and service was afterwards accepted by the United Company. The case came on in the Exchequer Division, before Mr. Baron Pollock and Mr. Justice Stephen, on 29th Nov., 1880, and occupied the attention of the Court on four successive days, being then adjourned for the preparation of the judge's decision. The facts of the case were not in dispute on either side, and the entire issue rested upon the interpretation to be given to the term "telegraph" in the Act above cited. The Attorney-General, for the Government, argued broadly that a telegraph meant an instrumental means of communicating intelligence, and if systematically undertaken by a third person in consideration of money paid, it would become an infringement of the Act even if the telegraph was not of an electrical nature at all. On the other hand, it was argued for the company that no communication by telephone was a telegram within the meaning of the Act, because the apparatus and methods are essentially different, and affidavits were put in, in which a number of distinguished men of science upheld the absolute novelty of the invention, and the impossibility of confounding the telephone with any existing type of telegraph.

Statements of this character were made by Sir Wm. Thomson, Prof. Stokes, Dr. Fleming, Prof. Tyndall, Lord Rayleigh, and Dr. Hopkinson. Upon the other side affidavits were read from Mr. Barlow (the inventor of the logograph), from Mr. Warren de la Rue, who described the Reis telephone, and from Mr. Preece, Sir C. Bright, Mr. Latimer Clark, and Prof. Hughes. On Monday, December 20th, Mr. Justice Stephen delivered a written judgment, the crowded state of the court evincing the widespread interest which had been excited. The judgment, which had evidently been prepared with the greatest care, and occupied a considerable time in delivery, is remarkable for the extremely able and discriminative manner in which the technical points are dealt with, and in this respect it contrasts most favourably with certain scientific expositions and definitions which have since been delivered from the Bench.

It is a matter of history that judgment was delivered in favour of the Crown. His lordship commenced by a careful and detailed description of the instruments and methods of working of the Edison Company, and after citing the clauses of the Telegraph Act which bore upon the question at issue, proceeded as follows:—"In simpler language, the Postmaster-General is to have the exclusive privilege of transmitting messages or other communications by any wire and apparatus connected therewith used for telegraphic communication, or by any other apparatus for transmitting messages or other communications by means of electric signals. The result of the definition seems to be that any apparatus for transmitting messages by electric signals is a telegraph, whether a wire is used or not, and that any apparatus, of which a wire used for telegraphic communication is an essential part, is a telegraph, whether the communication is made by electricity or not. It would include, on the one hand, electric signals made, if such a thing were possible, from place to place, through the earth or the air; and, on the other, a set of common bells, worked by wires pulled by the hand, if they were so arranged as to constitute a code of signals." It therefore appeared to him that, although there was no reason to doubt the statements of the distinguished men of science who had testified as to the novelty and the scientific merit of the instruments, yet he must hold their evidence to be beside the mark.

The arguments for the defence, which had been based upon the distinction in the method of working the telephone and the telegraph, appeared to him to apply equally to the Wheatstone A B C or the Hughes type writer, in neither of which was any distinctive code of signals employed. Still more did such reasoning apply to the Cowper writing telegraph; if, as had been said, a telephone line was merely an extended speaking tube, then the writing telegraph was nothing but a long pen. But although this instrument had not been invented when the Act was passed, no one would dream of asserting that its provisions did not apply thereto. He held that the telephone was a telegraph within the meaning of the Act. Judgment was accordingly delivered for the Crown.

Subsequent events have not in any way affected the opinion to which we gave expression at the time, that the decision was one which common sense, as well as law and equity, would uphold. The nation had acquired a monopoly of the telegraph system for the public service at a price and under conditions which proved the intention of the Government to acquire and maintain the exclusive control of any species of communication in which telegraphic apparatus were employed for profit. Had the decision been otherwise there was nothing to prevent the railway companies from equipping their lines with telephones, and competing with the Post Office for the transmission of public messages.

The United Telephone Company, upon the other hand, was probably well advised in putting the matter to the test, and although the royalty of 10 per cent. upon the gross receipts of the Exchange service, which, as a consequence of the judgment, is enforced by the Post Office, is undoubtedly a heavy burden upon their resources, yet it is one which they and their subsidiary companies have proved themselves perfectly well able to bear. The Post Office has, moreover, shown itself a generous taskmaster, and in the matter of long distance or inter-urban telephony, has acted with due regard to the public interest.

It should be here explained that in the Telegraph Act of 1868 private telegraph lines are expressly exempted from its operation, and it therefore still remains open to any individual or corporation to erect and maintain a line of telegraph for private use over any distance provided that such line terminates at each end in premises occupied by the same individual or corporation. Railway companies are thus entirely free from the control of the Post Office as regards their telegraph lines, so long as they are employed solely on the business of the company; and, similarly, the telephone companies pay no royalty on private lines erected for the use of a single individual. If, however, such a line be connected between premises in the occupation of two or more distinct persons, the royalty becomes payable in respect of such service. It is in part for this reason that the United Telephone Company has not seen its way to adopt any of the systems which are sometimes employed in America and on the Continent for cheapening the service, in say, suburban districts, by placing several subscribers upon a single line wire.

Before leaving this part of our historical survey we desire to correct any erroneous impression that may have been conveyed in the opening chapter by the passage relating to the British Post Office having rejected the offer of the telephone patent rights in the first instance. Those rights, it would seem, were really never offered to that or any other Government department of this country, the Crown having taken care to let it be known from the outset that they regarded the Telephone service as coming under the Telegraph Acts.

(To be continued.)

INCANDESCENT LAMP MANUFACTURE.—XXII.

BY J. SWINBURNE.

Testing (continued).

The chief consideration in the photometry of incandescent lamps is the standard of light employed.

It is strange that the incandescent lamp itself as a standard of light has not received more attention; it has been proposed, but the subject has never been thoroughly gone into. The first difficulties that arise are those of measuring the carbons. These could no doubt be surmounted by using a thick carbon,

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such as a graphite pencil lead. Such a carbon can be easily measured with sufficient accuracy. A perceptible proportion of the power is lost in the joints in large current lamps, but this can be eliminated by making two or more lamps with carbons of the same diameter, taking the same currents, but of different lengths; the resistance hot per inch or centimetre of carbon can thus be obtained. Only a part of the carbon need be exposed, so that the part that gives light in the direction required is all at the same temperature. The next difficulty is the alteration of the resistance with age. This can be avoided by defining the temperature as efficiency, and taking the power only into consideration, not the electromotive force or current. The errors due to differences in degree of exhausting are probably too small to be perceptible.

It is unfortunate that the Light Standard Committee of the British Association does not number more lamp makers among its members, as there would seem to be little difficulty in making an incandescent lamp standard of light which would be easy to use and accurate.

For practical purposes the Methven standard is the most convenient. This consists of a 16-candle argand burner with a screen in which is pierced a small rectangular hole, so that only a small portion of the light is thrown on the photometer screen. The hole is cut of such a size and in such a position that the light is equal to that of two candles. Mr. Methven finds that, if the flame of the burner is kept at a certain height, the light given through the hole is equal to two candles, whether the gas is of good or bad quality. Photometers with Methven's screens can be got from Messrs. Wright, Westminster. The photometers supplied must be altered before use, as the standard burner is movable, whereas it should be fixed, as it has to be close up to the screen so that the two candles may balance the light of the lamp tested, and the graduations are not then correct. The screen is the ordinary grease spot with mirrors, so that both sides of the screen may be seen from the front at the same time.

The lamp is mounted on a holder, which can be moved to and fro, so that the position of balance can be found. The first thing to do is to graduate the photometer. Suppose the lamps range up to 20 or 25 candles, the end of the lamp travel may be marked 30 candles. The scale is then graduated in candles from 30 down to one or two, which will come close up to the screen. A slide rule set for finding roots will save the trouble of calculating the positions of the marks.

If such a standard as the pentane or amyl acetate is preferred it is placed on the mark corresponding with the candle-power it is supposed to give, and the Methven standard is moved up to balance it. When the position is found, it is marked ·3 candle-power-watt, as the efficiency the lamps are to be tested at is controlled by the position of the Methven screen. If the photometer is in London, where the gas is fairly uniform in quality, and if the Referee's standard is preferred, the Methven screen may be taken off, so that the 16-candle burner is exposed, and this burner is then put with its centre the same distance from the grease spot as the 16 mark on the lamp scale. Any gas burner is then placed on the lamp scale, and moved till it balances the 16-candle burner; the screen is then replaced, and the Methven standard moved up to balance the second burner. The point at which it balances is marked ·3 again. The fault in a Methven standard is its inaccuracy when close to the grease spot. If instead of a flame a solid body were the source of light, the illumination of the grease spot would vary inversely as the square of the distance from the screen; that is, provided the screen is not so close to the grease spot that the solid angle subtended by the hole is different at different points on the grease spot. The flame does not emit light like a solid at uniform temperature all over, so that near the sides of the hole where the line from the grease spot would cut the flame obliquely—so that a greater length of it would be in the flame—there is more light sent to the grease spot. This inaccuracy is small, and does not make much difference in practical work, but it is best to fix the standard and move the lamp. If the Methven standard is moved, the pointer must be put so that the distance is measured from the plane of the screen, not from the centre of the burner or the point between the two, as it is sometimes. The Methven screen has the screen itself made of silver. It is difficult to see the reason for this extravagance, as a silver hole does not let any more light through than a hole of any other metal.

If it can be managed, the lamp should be run from secondary cells. The electromotive force can be adjusted as in the case of flashing. A final adjustment can be made by any form of rheostat which will absorb two volts or so. Of course a dynamo can be used, resistances being arranged to control the electromotive force.

A voltmeter and ammeter are also necessary.

The testing is done by girls, and there is sometimes some difficulty in getting any who understand decimals. The testers must find the volts and amperes needed to give ·3 candle per watt. If a lamp is run at random, and is found to give, say 13 candles, and to take 50 volts and 1·2 ampere, the efficiency might be got by dividing 13 by the product of 50 and 1·2, and thus finding if the lamp is too bright or too dull, and trying again, and so on. Such a process would be quite useless in commercial work; so it is necessary to arrange the apparatus so as to overcome the difficulty more or less. The best way is to use a wattmeter. The wattmeter is not graduated in watts, but in the candles a lamp should take at ·3 candle per watt. The tester then turns the lamp up to, say, 15 candles, and looks at the wattmeter; if it reads more than 15 candles it is too dull, and if less too bright, and she turns it up or down and takes a new reading. When the candles on the photometer agree with the wattmeter, the volts and amperes are read off on the voltmeter and ammeter, and the lamp labelled.

In large works the lamps need only be put into boxes or trays according to the volts, being classified as 16, 18, or 20 candle lamps. But if many lamps are used for arc light circuits it is best to label each lamp with the volts and amperes at ·3 candle per watt; the resistance or candle-power can then be obtained if wanted. If the lamps are all made accurately of the same surface they will of course come out at the same candle-power, and testing will be a very easy matter; but in practice they do not come out quite so well, and it is necessary to arrange the testing so as to work with lamps of all sizes.

The chief difficulty is to get an accurate wattmeter; a Siemens dynamometer will not do, as it is not direct reading. The wattmeter must also have its current coil of no appreciable resistance, and the pressure coil in shunt to the lamp and current coil, or else it must be compensated according to the writer's method. The same remarks apply to the voltmeter and ammeter used. If the ammeter is of very low resistance, so that the resistance of the ammeter and the leads are inappreciable in comparison with the lowest resistance lamp made, the voltmeter must be in shunt to both the lamps and ammeter, otherwise the current through the voltmeter will go through the ammeter too, and will cause serious error. The current through a voltmeter even of 8,000 ohms will cause a serious error if it passes through the ammeter when a 110-volt lamp is measured, especially if it is a 10-candle lamp. Similarly the loss of volts over the leads and ammeter may cause an error in a low-resistance lamp, such as for 10 amperes and 6 volts. The error is lowest when the voltmeter is in shunt to the ammeter, as the power absorbed by an ammeter is less than that taken by a voltmeter. This error can be compensated by arranging a few turns of the main circuit round the voltmeter backwards, so that they subtract an effect equal to that produced by the fall of potential over the leads and ammeter.

If a sliding voltmeter or sliding ammeter, such as the well-known graded galvanometers of Sir William Thomson, are used, they can be made to perform the calculation instead of the wattmeter, though not quite so quickly. The ammeter and voltmeter must first be carefully calibrated, and it will be found better to put in new scales, as the scales supplied read from 1 to 45, and the voltmeter is wanted to read to 120 or so, and the ammeter from ·4 to 1·5 for ordinary work. If the scales originally in the instruments are found correct at the position of the magnet box necessary for convenient

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readings, two new scales may be gummed to the glass inside them, and may then be marked to read directly in volts and amperes. The ammeter will now have three scales, the original from 0 to 45, one from 0 to 2·25, which is used for the current in the case of low-tension lamps, and one from 0 to 1·125 for high electromotive force. These scales are, of course, easily graduated from the original; but, if preferred, one new scale only may be used, reading from 0 to 1·5 amperes. The front of the magnet box is sometimes provided with a projection to facilitate reading its position on the scale on the wooden base, but if this is not provided, a piece of thin sheet brass may be soldered to the bottom of the box so as to project. On one side of the groove in the base borad marks are found by careful calibration, at which the scales read directly in amperes. On the other side a special scale is made, and is so marked that if a lamp takes, say, 60 volts, the ammeter, when the front is put at the 60 mark, will read the number of candles on the ordinary scale that a lamp with 60 volts and the current through the ammeter would give at ·3 candle per watt. Thus the mark for 66·6 volts is at the position in which there would be a reading of 20 with one ampere, and so on. This scale is very easily made by keeping a constant current through the ammeter and finding the position of the marks as the readings of the ammeter vary the numbers on the scale.

When a lamp of unknown candle-power is tested, it is run at, say, 17 candles. Suppose it takes 102 volts, the magnet-box is put at the mark 102 volts, and the reading on the original scale observed. If this is 17 candles, the lamp is running at the right efficiency; if the reading is less than 17 candles it is running too bright, and so on.

New readings are then taken with the lamp a little brighter, or duller, as the case may be, till the candle-power on the ammeter corresponds with that on the photometer. The magnet-box is then moved to the mark for reading the current, and the volts and amperes are read off and marked on the temporary label fixed to the lamp. If all the lamps are tested at the same efficiency it is only necessary to mark the volts and amperes, as the candle-power can be calculated from them. It is generally best, however, to have all three marked, as that affords some check on the testers, as if the watts multiplied by ·3 do not give the candle-power the lamp has been inaccurately tested. This is only a partial check, as it does not show that the reading on the ammeter really agreed with the candle-power of the lamp; but the girls who do the testing do not understand these points, and think that every lamp can be checked by mere inspection, and are therefore careful. The current should be taken to two places of decimals.

If a lamp has a flat carbon the ratio of the flat surface to the projection of the cylinder of the same total surface as the flat carbon is found by measuring the carbon with a michrometer.

The difference is allowed for by moving the standard lamp further from the screen. The standard lamp or gas burner is made to slide over a graduated scale, so that it can be put in the right position at once. If a lamp is to be tested at any other efficiency than ·3 candle-power-watt, the burner is moved to the mark corresponding to the efficiency required, and the testing is done in the usual way. The lamp is then labelled, say "80 volts, 1 ampere at ·25 c.p.w." If the candle-power is also to be marked on, the standard burner must be moved to ·3 candle per watt to take the reading, otherwise the candle-power reading would be wrong.

If the voltmeter and ammeter are of such a form that the sliding arrangement is not applicable, the photometer may have a scale attached which will perform the necessary calculations. The moving lamp holder has an index which not only reads the candles, but stretches over a scale which runs the whole length of the photometer slide. This is made of sectional paper, as usually used for curves. Lines are drawn parallel to the direction of the movement of the lamp. These lines correspond to the electromotive force from, say, 20 to 120 volts, so that if curve paper marked in 20ths of an inch are used, the whole scale is 5in. broad. Curves of currents are then drawn in such a way that when the lamp is giving any candle-power, such, for instance, as 20, the intersections of the electromotive force lines and the current curves under the index give the watts, in this case 66·6.

To test a lamp it is run at what appears to be about the right brightness, and moved till a balance is obtained on the photometer; the electromotive force on the photometer is then read. Suppose it is 65 volts. The long scale on the photometer is then referred to to see which current curve cuts the 65-volt line under the index. If this does not correspond with the current as read on the ammeter, the lamp is too bright or too dull, as the case may be. This method has some advantages over the first described, as if an ammeter is to be recalibrated it is not necessary to make a new scale. It is also quicker, as the ammeter needle takes some time to come to rest when the magnet box is moved nearer or further from the deflecting coil.

Some makers do not test their lamps on the photometer, as they think it would take too long. This is a great mistake, as the testing can be done very rapidly; one photometer can do 300 a day easily, and while lamps are so very expensive it is certainly worth while to test them properly. If the lamps come out of uniform surface the testing can be done very rapidly, because there is no adjustment to be made. If the surfaces are not all equal, testing lamps in batches against a standard lamp gives rise to serious error, which leads to the lamps being under or over run.

There seems to be a prejudice in favour of a long photometer. This seems to be a form of the same sort of fallacy as leads chemical balance makers to use long and heavy beams, instead of short light ones. The difference between a long and a short photometer is that in one case weak, and in the other case strong, lights are compared, and there can be little doubt that it is easier to compare two strong lights within a given percentage of error than two weak lights. If the photometer is very short there may be slight errors due to the lamp being so close that the illumination of the disc does not vary inversely as the square of the distance from the centre of the lamp. This never occurs in practice, however, and the Methven standard is calibrated in place, so that no errors arise from its being close to the screen.

CORRESPONDENCE.

THE FORBES NON-POLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I may point out that in the case of the field-magnet of a Forbes dynamo rotating round the fixed armature the relative motion is not, as Mr. Snowdon implicitly asserts, the same as when the armature revolves in the ordinary way within the fixed field-magnet, unless, in the former case, the brushes also rotate with the field-magnet, in which case the relative motion of the armature and brushes gives us what is practically, as I attempted to show in my last letter, a circuit of continuously varying area, and thus an E.M.F. is induced in the armature; but if the brushes as well as the armature were fixed while the field-magnet rotated, no E.M.F. would be induced in the armature.

Mr. Snowdon asks what the line *oc'* in my sketch has to do with the circuit.

It is as much part of the circuit as the line *oc*; the whole disc, and not merely the part of it on the straight line between the axis and the brush, gives passage to the current. Obviously the reasoning which applies to one part of the disc applies to another; any number of brushes may be applied to the circumference of the disc, as is done in the Forbes dynamo; but the only advantage gained by doing so is a reduction in the internal resistance. The E.M.F. is unaltered.

There was a slip in my last letter, where I said that the number of lines of force passing through the circuit varied from zero to a maximum and back to zero. Of course the number increases (or decreases) continuously at each revolution. I am sorry that I should have appeared to Mr. Snowdon to be dogmatic. Nothing was further from my thoughts. In

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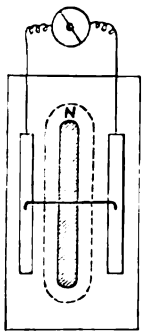
point of fact, the statement which he thus characterises was one which I attempted—not, apparently, to Mr. Snowdon's satisfaction—to prove.—Yours, &c.,

Park-square, Leeds. BERNARD P. SCATTERGOOD.

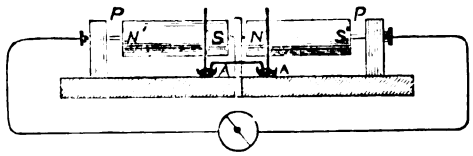
TO THE EDITOR OF THE ELECTRICIAN.

SIR: As Mr. Scattergood did not take kindly to my remarks—which were intended for the vindication of scientific truth rather than to "stigmatise" Mr. Scattergood or anyone else—I enclose a drawing of an experiment which shows simply and clearly that it is possible and desirable to obtain current by the movement of a conductor in a uniform field. N is a wide, flat electro-magnet seen end on. A detached field-magnet of a Siemens machine would do admirably and give emphatic results. A board with a slot is fitted over the core of this magnet. Two parallel troughs are cut in the board, one on each side of the magnet. The troughs are filled with mercury. A wire, W, is the movable conductor, and bridges the magnet by going from one mercury trough to the other. The galvanometer closes the circuit by being in contact with the troughs, as shown. So long as the movement of the conductor is confined to the magnetic area the field may be regarded as infinite to it. In fact, the magnet if made in a curved shape would be a segment of a circle, which, if complete, would be infinite indeed. If, now, the conductor is moved along the troughs a current will be indicated at the galvanometer; and, of course, by having a battery in the place of the galvanometer, the conductor, if floated, will develop a mechanical movement by gliding over the magnet. This I take to be the ideal method of mechanically generating electricity, because the moving wire is continually subject to a maximum magnetic potential, neither increasing nor diminishing the lines of force cut by it. It will be seen that any number of moving wires could be arranged side by side, but the difficulty is to get them in series. Enormous quantity currents may be obtained, but of low tension. I could show at least half a dozen experiments that prove beyond doubt the possibility of producing current under such conditions, but I hope the above will be sufficient to convince Mr. Scattergood. And now for Mr. Thompson. So far from being anxious to show that the pivot arrangement in the experiment shown in my previous letter was practically uninfluenced by the lines of force, I more particularly resorted to it to convince Mr. Thompson of what I believe to be his error, because he laid such stress on his idea that the two fixed conductors were unequally "cut" by the "rotating" lines of force, this fact, according to his view, accounting for the production of current. Mr. Thompson now admits the pivot is practically out of the field so far as the supposed moving lines of force are concerned. I hold that the magnetism is stationary and independent of the molecular construction of the magnet. Therefore, to me, it matters not whether I make contact with the magnet by a pivot or a drum so long as the conductors are fixed, because fixed conductors cannot cut fixed lines of force. It is only the movable conductor that produces the current—viz., the rotating magnet.



Mr. Thompson shows two diagrams; one Faraday's and the other Weber's. I do not remember having seen such an experiment in Faraday's works, but let that pass. In No. 1 diagram, Mr. Thompson treats the disc "simply as a conductor neutral to the action of the force, inasmuch as it revolves with them." But in speaking of the disc as the conductor or generator in No. 2 diagram, he says:—"Here it is evident that the conductor at the centre could cut more lines of force, &c.," so that the rotating disc in No. 2 he evidently regards as the generating conductor. In both diagrams Mr. Thompson assumes the lines of force revolve with the magnets. In both cases the discs are subject to the same inductive influence, and in both diagrams they are affixed to and rotate with the magnets. Now, how can the disc in No. 1 be "neutral" while the disc in No. 2, moving under the same conditions, is the generator? Clearly, Mr. Thompson contradicts himself. I shall be interested to know what grounds Mr. Thompson has for assuming that the current emanates from the wire length *x*, *y*, in his diagram, rather than from the moving disc. An expert electrician without a theory on this subject would be unable to decide which was the generating conductor, so the experiment decides nothing.

Fig. 2 is a design for an experiment which, I think, would throw some light on the question. I have not tried it; but many of your readers will be able to foretell its action, while some, perhaps, may have facilities for putting it to the test. N S are two magnets separately mounted on pivots so as to rotate independently of each other. A thin iron standard goes between them, and supports the pivots. A flange is affixed to each magnet near to the inner poles. Each flange dips into a trough of mercury, and these two troughs are electrically connected by a wire bridge, A. The fact of N and S, the middle poles, being together would cause the lines to be continued throughout the magnets, so that the two would be practically one magnet. There would certainly be some external lines of force at the middle poles, but in comparison



to the extreme poles, N^1 S^1, they would be few. Here, then, we have a system that in all respects resembles a single bar magnet divided at its equator. The lines of force extend from N^1 to S^1, the outer poles, the same as in a bar magnet. Now, let one half of this compound magnet be rotated in one direction, and the other half in the opposite direction, and a current will pass from pivot P along the surface of the magnet by the wire A, and the other pivot P^1, completing the circuit through the galvanometer. But what becomes of Mr. Thompson's rotating lines of force now? Are they crumpled up, doubled up, or torn asunder like bits of string? Or are they infinitely elastic and capable of unlimited twisting? Surely there would be a magnetic catastrophe in this case, if we could only see it. Assuming for the moment that the lines do revolve in opposite directions with the magnets, how is the current generated in this experiment? Where is the fixed conductor that can even remotely be supposed to be cut by any "moving" lines of force? It is impossible to explain the action on the rotating lines of force theory. How different if we seek for an explanation by regarding the lines of force as a fixed element. Under such conditions it matters not which way each half of the magnet revolves, and its own electric conductivity is enough to account for the production of current as its molecules cut the fixed magnetism. Mr. Thompson trips me up somewhat sharply by asking "How a quality such as conductivity can itself be a cause of action?" We know that oxygen is not the cause of animal life, and we know equally well that animal life cannot exist without oxygen, and it would not be wrong if we were to say that animal life exists by reason of oxygen. By the same reasoning, although conductivity is not the cause of electric action, it is an essential quality for the manifestation of its effects. I know not which is of the more importance, the cause itself, or that quality which allows its effect to be made evident to us. Therefore to say that a current exists by reason of electric conductivity—inasmuch as it does not exist without this quality—is, I think, sufficiently logical for our purpose. Mr. Thompson asks me to explain, on my theory, how current can be produced in two discs on the same axis. If you, Sir, can find space, I will do so in my next letter.—Yours, &c.,

E. L. VOICE.

6, Betterton-street, W.C., Aug. 16, 1887.

[CORRESPONDENCE *continued on page 315.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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THE ELECTRIC LIGHT COMPANIES.

As the season of annual meetings advances we are enabled to form some idea of the financial condition of the Electric Light Companies and of the prospects before them in the coming year. On the whole there are reasons for hopefulness all round; and if the business of the Edison and Swan Company, whose yearly meeting we reported in our last week's issue, be taken as an average example of what the companies severally have been doing, their shareholders may very well be satisfied with the progress Electric Lighting is steadily making. Under its new management this company has been improving, and the year just reported upon shows a business profit of £16,221, a sum which, although at present not available for anything but paying off arrears of debt, is large enough to give promise of dividends at no very distant date. The doleful particulars relating to Electric Light Companies furnished by *Burdett's Official Intelligence*, and reprinted in our "Notes" of last week, reveal chiefly the state of affairs down to the middle of last year, since which time they have taken a turn for the better, and to such an extent that a dividend-earning period may now be confidently looked forward to.

We are, however, far from wishing to minimise the gravity of the figures to which we have just referred. They indicate that some of the companies were earning very little, and that others were scarcely doing more than paying their way. This is no doubt very discouraging to investors; but it may be well to point out here that the figures only relate to Companies, and that private firms are doing the self-same class of business with a fair return for their outlay. The cause of their comparative failure hitherto in the case of Electric Light Companies is not far to seek. They have expended vast sums for patent rights, and have competed with each other for business at unremunerative prices. Despite the prohibitive legislation of 1882 there is a great deal of Electric Lighting being done, and the area of operations is rapidly enlarging. In reality, the business, considering how young it is, has made wonderful strides, and if it does not pay, the fault is not with the business but the people who carry it on. Here, for example, is a company making a profit last year of over sixteen thousand pounds, and this on transactions by no means gigantic. Any private firm of moderate dimensions—such a firm as, indeed, would be quite large enough to do twice or thrice as much work—would be amply satisfied with the profit just named. This fact is worth emphasising, because if private firms engaged in the business of Electric Lighting are unable to command their legitimate profits, it must be because their competitors are struggling for business which in the aggregate is considerable, but the profit on which is reduced to the finest point. Our contention is that the Electric Lighting business is flourishing, but that it cannot possibly pay the number of people engaged upon it, or, more correctly, the amount of capital invested in it.

That the capital of the Companies was far too large is proved by the wholesale reductions which took place a year or two ago, and which may possibly have to be repeated. The capital is not an available asset, and, worse still, it is not a working capital. In both these respects the private firm has greatly the advantage of probably every Electric Light Company in existence. It is perfectly astounding to hear these Companies talk of their respective capital as half-a-million or more—a capital out of all proportion to any prospective return that they could ever hope to earn. For it must be remembered their capital represents not money that can be employed for promoting and extending business operations; it has gone to pay for patent rights and for defending them in Courts of Law. These patents appear to have been paid for on a scale which, had they been certain to supersede all existing railroads, or render useless all existing telegraph wires, or to extinguish every gaslight in the kingdom, could hardly have been higher. Except and beyond the value of these patents for which such fancy prices were paid, most of the companies are poor, and have to save themselves becoming poorer by defending the rights they own or acquiring others which threaten them. In his speech at the meeting of the Edison and Swan Company last week, the Chairman said that after some considerable experience he had arrived at the conclusion that any one who stakes his money on a patent is a fool. He presently explained that he meant "until the validity of the patent has been established." He might with more reason have said "until the value of the patent has been ascertained." Patent rights, like patent medicines, are never quite safe unless they are worthless.

The craze which possessed the investing public a few years back appears to have not yet been exorcised. Every now and again there is put on the market some mysterious discovery which is to give to Electric Lighting industry the fillip it is supposed to be in need of. In reality, it needs no such artificial aid; but if it did, the very worst that can happen to it will be a revival of the mania for buying patent rights at fabulous prices. As a rule these discoveries, like the one we commented upon last week, are worth just as much as they will fetch to the vendors, and exactly that much less to the buyers. We have said this many times before, and

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we repeat it again just now, partly because the warning is needed, not for the general public only, but for the shareholders in existing Electric Lighting Corporations. Unfortunately promoters are never wanting to take up any new scientific scheme which a non-scientific press can be induced to back up, and an ignorant public to swallow. The proverbial, and often quite ingenuous, enthusiasm of the "discoverer" is a quite contagious influence in the transaction. As we are penning these lines a letter reaches us from the States, inviting us to introduce the writer to "your people"—meaning the English investing public—to take up his idea of telephony, which will enable us to telephone clearly and distinctly through "3,000,000 miles of submarine cable." The idea has a basis of truth but a superstructure of nonsense. What the truth is does not signify, for it is not new and it will not do. But the nonsense will or may do a great deal. "The direct route core will reproduce *instantaneously* from the narrow spout through which the current goes, [just] as, for instance, water with a given force will obtain greater velocity through a narrow spout, as compared to a wider or larger one. The outer surfaces [of the inventor's wire] will take up all inductive adjacent sounds (air waves), and by their spiral velocity will be thrown off the wire and return to the atmospheric undulatory movement." Now, this is the sort of thing that fetches; we seem to be reading something from *The Times* newspaper; and it does not surprise us to learn from another part of our amiable correspondent's communication that he is already doing business in the United States, and is prepared to dispose of his "rights" in the British Isles. Nor would it surprise us very much if British money is some day forthcoming to buy this man at his own valuation. All that we can do is to warn the public off new inventions unless they understand them, and the companies off patent rights unless they want them and can get them a bargain. What the Electric Lighting Companies have to do is to push their business vigorously, and to conduct it so well that their reputation will outlive and outweigh all the patent rights they now, or ever can, possess.

PROF. FORBES' DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Snowdon in his last letter complains of not having received the information he sought, and on reference to his inquiries, published in yours of the 1st ult., I find he says, "I can understand that all will be well if the rings of magnetic force encircling the exciting coil" (of Prof. Forbes' dynamo) "are held *quasi* fixed by the current in the coils, but if that were so it would answer as well to rotate the coil instead of the armature." Now, the whole of the correspondence on this subject has turned on the question whether the field is fixed by or independent of either the coils or the magnet, as the case may be. Mr. Snowdon and Mr. Voice both maintain its independence, while I as stoutly uphold the reverse. There has, so far as I can see, been no solid objection brought against the theory of a fixed and dependent field, but only an endeavour to establish the other, which has not been too successful. In answer to the latter part of Mr. Snowdon's inquiry, I do not see why he should not get current under the conditions mentioned, but it would be very feeble by reason of the absence of the core. Mr. Snowdon is possibly right in assuming that the disc of the machine in question would tend to carry the field, but this action, I maintain, would be resisted by the field itself, and would be of the nature of a permanent strain in giving distortion, not motion.

To produce resultant force of an electric nature, I maintain that it is necessary to oppose the mechanical action given to the molecules of the armature when revolving by a field force of magnetic nature, on very much the same principle that mechanical forces brought into collision may be made to produce such physical forces as heat, sound, &c. In this I differ from Mr. Voice, who assumes that it is possible to produce such resultant phenomena as dynamic electricity without the interposition of a reactive agent.

From careful perusal of Mr. Snowdon's last and previous letters I understand him to maintain that the armature of a machine of the type under discussion would cause the field to revolve, and that the field in its course is first opposed to the resistance of the field-magnet core by reason of the induced currents it generates therein; that this opposing action causes a reduction in the velocity of the field, which now reacts on the armature that is passing it at a higher velocity. If this is a correct statement of his theory there will be little difficulty in showing its fallacy; but first I may remark that Mr. Snowdon's endeavour to account for resistance in the core of the field-magnet by heat produced by the direct action of the field is not very satisfactory. Mr. Snowdon knows well that the Foucault currents are by far the most potent, if not the only cause, and that any heat developed as he suggests would be much too insignificant to give, in his theory, the necessary reaction for the powerful current generated. But I will treat Mr. Snowdon's theory on more definite grounds; I will assume that the magnet core does oppose the necessary resistance, and that the consecutive actions are as stated.

We are given to understand that the field as a whole is impelled by the revolving armature or disc. How, then, about the magnet core? If the armature passing the core is the same in effect as the armature and core revolving in opposite directions, would they not both possess the same property, and exert equal but opposed strains on the field? Where, then, would be the field's motion? Of course, something must give, and according to Mr. Snowdon the giving would be in the molecules constituting the armature and core; but if the impelling action of the forces (treating the armature and core as two bodies revolving in opposite directions) on the field molecules is dependent on the power of the induction effected, it will be evident that the same result will be arrived at, as the resistances of the armature and core to induction will be equal and opposed. If Mr. Snowdon's hypothesis were true, it would not be possible to return as useful effect in the armature of this machine more than 50 per cent. of the original energy imparted. I wish, Sir, to correct an error I made in my last letter, to the effect that velocity would vary as the square of the radial distance. I had in my mind at the time the total effect of the varying velocities on the molecules of the conductors in question, which would of course vary in this ratio. This mistake does not, however, affect the main question at issue, and the measures set forth for the course of current will still retain their force. I may also remark that the sentence relating to a magnetic field at the end of that letter should have run "and it is the ether atoms or molecules under the influence of velocity, &c.," and not force as stated. Perhaps, to meet the alternative theories of a magnetic field, I ought to have said "under the influence of velocity or strain, &c."—Yours, &c.,

N. G. THOMPSON.

4, Queen Victoria-street, E.C., Aug. 16th, 1887.

THE OERLIKON DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your notice of the Oerlikon dynamos you question the advantage of threading the armature wire through holes punched in the iron, because a path is afforded for the lines of force to cross from pole to pole round the periphery of the armature without passing through the windings. As, however, the iron between the edge of the holes and the outside of the armature is only half a millimetre or less in thickness, I think you will agree with me that the number of lines that take this path instead of the shorter and easier one through the unsaturated mass may be neglected. I cannot understand how the iron of the armature can under any circumstances "tend to increase the

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magnetic resistance of the whole of the field iron." Doubtless there is some error here, as there is in the statement that the machine was designed for an output of 50 horse-power when the electrical return is 115 volts and 440 amperes. With regard to the magnetic circuit being rather long, I can only say that I have been under the impression that in machines of this type it is short. As to the leakage across the horns of the field-magnets, I think it may be neglected in a machine that has a magnetic circuit wholly of iron except for the very small air clearance between the smooth iron armature and the iron of the field-magnets.—Yours, &c., C. E. L. BROWN.

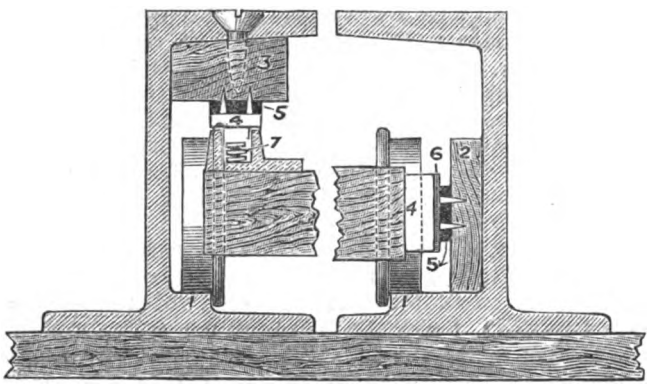
Oerlikon bei Zürich, 15th August, 1887.

[Mr. Brown must surely be aware that the magnetic resistance of iron increases with the magnetisation. Consequently, if a number of lines traverse the field-magnet circuit without cutting the armature coils, it is obvious that such lines merely tend to increase the magnetic resistances of the whole of the field iron. However, we have no wish to lay any stress upon the point, especially as Mr. Brown points out that the rim is only 0·5 mm. in thickness, and we are glad also to have a correction of the misprint of 50 horse power instead of 60 horse-power.—ED. *E.*]

THE BIDWELL ELECTRIC RAILWAY CONDUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have noticed your description of Mr. Bidwell's "invention" for "improvements in electric railway conduits," and express my agreement in your remarks upon the design by sending you an extract from one of my earlier blue books.



The drawing is exactly as printed; two methods are shown in one view.

Bidwell's (?) detail for making the upper part of the channel removable, and his method of connecting the collector with the car are also shown in other sketches, which I can send you if necessary.—Yours, &c., M. HOLROYD SMITH.

Halifax, Aug. 16, 1887.

Extract from Specification.

"Fig. 14 illustrates a section of trough wherein a ledge of the lower portion of the trough serves as rails for the wheels of the trolly. The position of the conductor bands 5 is changed, in the one case being attached to the insulating block 2 at the side of the trough, in the other case the conductor bands are attached to the insulator block 3, and in each case the collector 4 is kept in contact with the conducting bands by means of the blade or spiral springs 6, 7. In these cases two bands may be used, one for the flow and one for the return, or only one for the positive, the return being by way of the wheels of the trolly through the metal of the channel."

"ELECTRO-DEPOSITION."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On reading the review of my work on "Electro-Deposition" which appeared in your last issue it was impossible for me not to recognise, in its style and matter, the authorship of a similar review which appeared in *Nature* on April 1, 1886. Nor is it difficult to trace in both critiques the hand of *a competitor*, by which I mean one who has himself written a work upon the same subject. When comparing these two reviews, the one which appears in your own journal reads like a parody upon the one in *Nature*. The same references, the same quotations, the same terms, the same objections or complaints, and the same commendations occur in each; but occasionally a slight modification of terms is adopted in your version, so that it may not read quite like an exact copy of the one in *Nature*. In both of the reviews referred to, the critic has been pleased to represent me as a kind of floating "electro-plater"—one who has "spent a *large* (!) period of time in manufactories of electro-plate," or, as he puts it in your contemporary's columns, "spent a *long* period of time in electro-plate workshops." Now, if I am not mistaken in my conjecture as to the authorship of these reviews, the writer must have known that in my professional capacity of consulting electro-metallurgist, I must necessarily visit from time to time numerous establishments to impart such advice or instruction as might be required from one whose experience in electro-deposition has extended over a period of nearly half a century. To style me an "electro-plater," in the ordinary sense, is, therefore, somewhat misleading, as your reviewer should know that besides being author of a long series of works of a more or less useful kind, I am also one of the oldest scientific journalists in this country.

Having called attention to the identity of the two reviews in question, I will now, with your permission, refer to the complaint that my book "is seriously deficient in the chemical, the thermo-chemical, the electro-chemical, and voltaic principles of the subject." Now, the reviewer must have known, from the title of my work, that it was intended to be a "practical treatise," and as such the elementary matter to which he refers should have no place, in my opinion, in a book intended chiefly for practical readers. Moreover, I had heard so many complaints from practical men, that Gore's book on "Electro-Metallurgy" contained "too much scientific and useless experimental matter" to render it of any service to practical operators, that I determined not to fall into the same error. Knowing my *clientèle* and their requirements well, from the abundance of correspondence which has reached me from all parts of the world acknowledging the usefulness of my former work "Electro-Metallurgy Practically Treated" (Weale's series), now passing through its ninth edition, I purposely avoided entering deeply into the theoretical part of the subject, leaving the readers to seek such knowledge from works specially devoted to chemical and electrical instruction.

On page 80 of my book (to which your reviewer refers), the chapter (Chapter V.) opens as follow, the words in italics having been designedly omitted by him in order, I presume, to pervert my actual meaning:—"*While it would be beyond the province of the present work to enter deeply into theoretical considerations*, it is necessary, in the present advanced state of electrical science, that both the student and practical operator should be acquainted with the principles and laws which govern the development of electricity, &c." The object of mutilating this paragraph by leaving out the words in italics speaks for itself; but surely such a method of quotation for the purposes of adverse criticism cannot be too highly reprehended. Again, the reviewer disregarded the concluding sentence of the same paragraph, which runs thus:—"For a full knowledge of the laws of electrical science the reader is referred to standard works on electricity," &c.

I was somewhat amused at the cunning with which the critic connected my remarks upon "mystery gold"—an alloy of copper, platinum and silver, and manufactured specially to defraud pawnbrokers—with a method I had described for gilding "cheap jewellery"—that is, articles made from brass or gilding metal. The latter class of articles, being retailed at only a few pence each, are not usually confounded with what is known as "spurious gold," and a mere "dip" in the gilding bath on the most economical terms possible would be the only conditions under which such work could be gilt at a profit. Although I appear to have shocked your critic's high sense of morality by stating that I

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had found a *copper* anode most advantageous for gilding goods of this description, I must adhere to my statement and leave my censor to recover from his perturbation as best he may.—Yours, &c., ALEXANDER WATT.

London, August 16th, 1887.

[We have inserted Mr. Watt's letter, although we do not approve of the growing habit of authors criticising reviewers. We are absolutely ignorant as to the personality of the *Nature* reviewer, nor are we to blame if Mr. Watt's book was reviewed in our contemporary in 1886. His publishers did not forward us a copy for review till the middle of the year 1887, and we in our innocence imagined the work only recently published. It by no means follows that because two reviewers condemn or praise similar portions of a book that the two reviews are by the same hand. If the reviewers are competent they are compelled to condemn the same faults and praise the same good features. As a matter of fact a considerable portion of the review of Mr. Watt's book was deleted editorially owing to the exigencies of space, and had the review in its entirety gone in, Mr. Watt's opinion as to similarity might have been modified. Mr. Watt really uses his imagination to make a covert attack on the work of a "competitor," and we think has in this letter laid himself open to retaliation. The work of Mr. Watt has been and is highly appreciated, and in our estimation he should welcome what he terms adverse criticism, if only to enable him to make future editions unassailable.—ED. *E.*]

THE MAGNETIC FIELD OF THE THOMSON-HOUSTON DYNAMO.

The figures illustrating this paper and the comments thereupon are taken from an article by Mr. Carl Hering in our contemporary, *The Electrician and Electrical Engineer*, of New York, where they formed part of a more extensive contribution to the subject. It happens, however, that the majority of the machines whose magnetic fields have been examined by Mr. Hering were of old-fashioned type—as the Edison machine with 12 magnet limbs—or else have obtained no footing in this country, so that the chief interest in the paper lies for us in the investigation of the Thomson-Houston dynamo. It may be taken for granted that every one has already agreed that this machine is magnetically of extremely bad design, and a certain authority has even expressed surprise that the machine can be got to work at all. After examining the diagrams we should say that his astonishment will be considerably increased. Yet we know that the Thomson-Houston machine is, at least for arc lighting, a thoroughly practical success, and we are not aware that any complaints are made as to its efficiency. It is, of course, true that mere leakage lines do not imply a corresponding increase of exciting power until the saturation point is approached, but as arc light machines, working as they do on the horizontal limb of the characteristic, such lines must still represent a certain waste of E.M.F. in excitation, even if they do eventually pass through the armature.

Mr. Hering thus describes his method of examination:—

The exploring needle was an ordinary short, light, compass needle, strongly magnetised, and loosely supported on a pivot. While the dynamos were running and the magnets fully excited, this needle was moved about in the space surrounding different parts of the magnets and the machine frame. If the case containing the needle be turned so that the needle is always perpendicular to its pivot, thus allowing it to turn as if on a ball and socket joint, the needle will take the direction of the lines of force in this space. By moving it systematically all around the different parts of the machine, and by plotting the direction of the needle on outline drawings of the machine, the directions of the lines of force may be readily indicated. To explore the curved paths of the lines of force the needle may be held near to any particular part of the frame and then moved continually in the direction in which the farther end points—that is, as the direction of the needle changes, the direction in which it is moved must be changed so as always to conform with that to which the needle points. The path which it describes will then be that of the particular line of force. In this way the curvature and the two terminals of an external line of force can be determined and plotted with all due accuracy, as the needle is always a tangent or short cord to that curve, and where the needle points directly to the iron when held closely to it, it indicates the point where the line enters or leaves the iron. By shaking the needle to cause it to oscillate, a rough approximation can be obtained of the intensity of the field or the number of lines of force at different places. Great care should be taken not to move the needle too fast, as the lines of force in some machines make such short curves that the needle is demagnetised and even reversed in polarity before it has time to turn on its pivot. It is necessary, on account of this possible reversal of the magnetism, to test frequently its polarity at one of the machine poles, otherwise very queer and conflicting curves may be obtained.

It will greatly facilitate the examination and plotting of these curves to remember that every line of force appears to make a closed curve which encircles the wire through which the exciting current flows. This will also enable one to interpolate the probable return paths of the lines in the iron where their presence cannot be ascertained by means of a needle otherwise than by their external manifestations. All lines which do not pass from the pole-piece to the armature core, and are therefore not cut by the armature coils, are wasted and represent leakage.

In the accompanying diagrams the probable return paths of a few of the lines of force in the iron parts have been indicated, and it is believed they are correct. The drawings may not in all cases represent the exact proportions of the frame, as they are copied from mere rough note-book sketches.

The field around the Thomson-Houston machine, shown in Figs. 1, 2, and 3, proved to be one of the most interesting, some of the curves being of a very peculiar nature. The magnetism was so intense in several places and the lines made such sharp turns that the exploring needle was repeatedly reversed in polarity during the examination, thus giving absurd results. It was not until the needle was repeatedly tested for polarity, and all results obtained with a reversed needle discarded, that any conclusive results could be obtained. The test was furthermore rendered difficult at first by the fact that the direction of the lines of force could not be tested in one plane only as in the other machines, as they curved around in different planes in such a way as to make it difficult to represent their courses on the plane of the drawing. In order to be sure that the results were correct the writer recently repeated the tests very carefully on a new 30-light arc machine, and obtained the results shown in the figures, which are believed to be substantially correct.

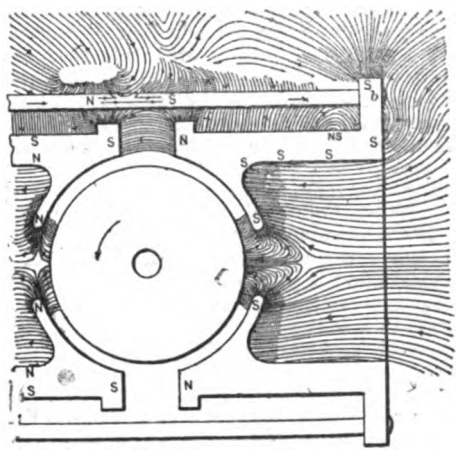

Fig. 1.

Figure 1 shows more than half of the vertical cross-section through the centre, taken perpendicularly to the shaft. The coils are wound around the large, hollow cast-iron cores which terminate at the armature and at the ends of the machine, one of which is shown complete. There is a round opening in the thin shell which embraces the right and left hand sides of the armature. The intended yoke-piece consists of a series of horizontal, round, wrought-iron bars, two of which are shown, one above and the other below the armature. As in the Van Depoele machine, there was a very strong leakage from the magnets to the yoke-piece, especially at and near the ends of the pole-pieces, showing that many lines of force were magnetically shunted around the armature, and were therefore wasted. A neutral point was found near the right hand end of the core, as shown. Immediately above the bars of the yoke-piece a strong field existed which showed the same polarity as that between the yoke and pole-piece, as indicated by the arrows, showing that these yoke-pieces had two strong poles one above each of the pole-pieces, but of opposite

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polarity to the latter. Immediately above this field and represented by an open space, the needle exhibited that peculiar state of unstability, indicating a point of deflection, while above this space it again had a definite and decided direction. In this space, left blank on the figure, the lines were found to be perpendicular to the plane of the drawing, as is shown more clearly in Fig. 2, which is an enlarged vertical cross-section taken through the north pole-piece perpendicular to the bars of the yoke-piece. As shown in this figure the lines passed from the pole-piece into the yoke-piece on all sides, while the others from the pole-piece pass out into the air between the bars, thus forming above the bars at about the relative distance shown, a point of deflection having four poles, similar to that in the Edison and Weston machines.

Referring to Fig. 1 a peculiar deflection of the lines was noticed almost directly above the south pole-piece, which was somewhat similar to that observed in the Van Depoele machine. It is possible that this was due to another point of deflection existing in the iron, as indicated in Fig. 1, with four or possibly six poles, but these curves in the iron itself are probable conjectures only. A similar deflection was noticed a few inches to the left of this point.

In moving the exploring needle vertically above the north pole-piece, it was found to turn abruptly through almost 180deg. a few inches above the yoke-piece, as shown by the arrows, while nearly above this there was a deflection similar to that in the Van Depoele machine. This was found to be due to a point of deflection existing between the bars, but above them, and is shown more clearly in Fig. 3, which represents a portion of a section like Fig. 1, but between the bars. This point was clearly indicated by the needle, and assists in connection with Figs. 1 and 2 in explaining some of the peculiar curves noticed above that part of the yoke-piece which lies above the pole-pieces in Fig. 1.

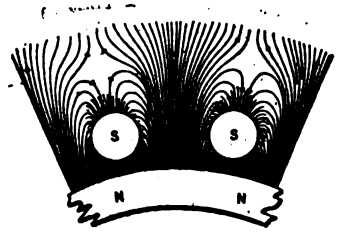

Fig. 2.

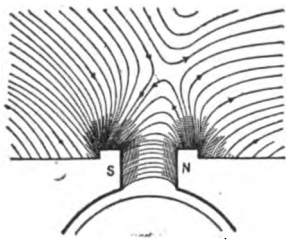

Fig. 3.

At the right hand end of the core the usual strong pole was found. A peculiar curving of the lines was noticed at *b*, where the rounded projections of the wrought-iron bars passed through the flanges. A possible explanation of this is that the cast-iron flange is over-saturated to a greater extent than this projection of the wrought-iron bar, which, therefore, attracts the lines.

Following the surface of the core to the inside or hollow portion, a weak south pole was found to exist on the cylindrical surface, while on the interior flange embracing the armature the south pole was found to be very strong, the lines from it passing out through the open end. By placing a small needle very near the revolving armature and in the opening in the iron it was found that many of the lines from this south pole entered the armature. From the general principles underlying all other dynamos it would be supposed that the polarity of the pole-piece embracing the right hand half of the armature was the same in all parts, but it appears from the external lines of force which could be examined that this is not the case with this machine, as there is a strong north and a strong south pole on different parts of the same pole-piece. Careful and repeated examinations with the exploring needle on the same and on different machines clearly shows this peculiar disposition of poles to exist.

Near the opening, through the centre of the core, was another point of deflection with four poles, which in some machines was found to be very near the armature, as shown on the left hand side, while in others it was located several inches from the armature as shown on the right hand side. The lines of force at this point were very intense, and their curved directions are very decided ; for this reason it was found that a very short needle had to be used and that it had to be moved about very slowly to prevent it from having its polarity reversed before it could respond to the change of direction. By moving the needle rapidly from the armature through this point of deflection, its polarity can readily be reversed, and it will then point in the same direction as it did before passing the point, thus making it appear as if there was no point of deflection. Moving the needle towards the armature will not reverse it so readily, as these curves are less abrupt. The lines of force at this point appear to oscillate very rapidly, which is probably due to the pulsating character of the magnetising current. It is quite probable that the curves shown in all these figures would change very much with different degrees of saturation. A careful study of the curves of each machine at regularly increasing degrees of saturation might lead to a determination of the best proportions and shapes of the iron parts.

Fig. 1 is a good illustration of how not to proportion the parts when the best economy of magnetisation is desired. At the same time it must not be forgotten that the energy used to excite the magnetism is for the best machines only a few per cent. of the whole output, and that, therefore, any improvements in the frame that would economise magnetism would only lessen this already small fraction, and possibly in some cases economise material. Other conditions may be of so much more importance as to make an increase in the economy of magnetism of little significance in comparison. The fact that the Thomson-Houston machines are used in such large numbers, shows that great economy of magnetism is not one of the most important points about a machine.

From the nature of the fields surrounding a dynamo, as shown in the figures, the following general deductions may be made :— That machines exhibit the following magnetic properties : Free north and south poles, neutral points of two different polarities, and points of deflection. The latter exist in the external fields, but may possibly exist also in the iron itself ; they generally appear as four curvatures of the lines of force towards and receding from one point, and are in that case enclosed by four free poles and four neutral points of alternately opposite polarity.

OKONITE.

Okonite is an improved variety of a rubber composition which has been long and extensively applied in America as a waterproofing material, and for other purposes for which rubber fabrics are generally employed. It appears to be peculiarly well adapted to resist the American climate, and coats waterproofed with it last a very long time. The idea occurred to Mr. J. J. C. Smith, of Passaic, New Jersey, U.S.A., that this material might be also used for covering electric conductors ; but his first experiments made in this direction were unsatisfactory, the original material not being sufficiently waterproof, besides lacking certain mechanical qualities which are essential for perfect insulation. Mr. Smith thereupon set to work to improve the material by mixing it with other ingredients, and of each composition large sheets were made and suspended by the four corners. Water was then poured into these sheets, and the rate of leakage observed. Having in this way found that composition which is most impervious to water, Mr. Smith concluded that it would also be the best insulator, and began to apply it for that purpose. The precise constitution of this material is a secret, but the inventor states that it contains 38 per cent. of fine pure caoutchouc and 62 per cent. of some natural hydrocarbons, oxides, and silicates. The composition is applied to electric conductors in the following way :—It is first rolled out upon sheets of stout tinfoil, and the two surfaces are made to adhere slightly by the pressure of the rollers. These compound sheets are then cut into strips of slightly greater width than required to wrap round the wire with a longitudinal seam. The strips of okonite with their tin backing are then joined end to end, so as to form one long continuous band, which, for convenience in the subsequent process, is coiled upon a reel. The tin backing, however, was not the first employed by the inventor. Originally the backing was of woven fabric, and sufficient pressure was applied to make the okonite enter into the fabric so that the two surfaces adhered firmly. These sheets were drawn over a large metal cylinder and their edges joined. The continuous tape was then produced by making a spiral cut over the surface of the cylinder with a revolving knife. The wire to be covered is also wound upon a reel, and both tape and wire are simultaneously passed through a machine, by which the insulator is laid on longitudinally instead of spirally. The principle of covering wire with an insulating compound laid on longitudinally instead of spirally is not new in itself, having been applied, as early as 1848, by Messrs. Barlow and Foster, who placed the wire between two heated fillets, made to adhere to each other in two longitudinal seams by passing between two suitable rollers. Mr. Fleetwood, in his recent paper read before the Society of Telegraph-Engineers and Electricians, also mentions a machine, patented by Mr. John Lewis

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Ricardo about the same time, which consisted of a pair of grooved rollers, through which were passed several wires placed parallel between two fillets, the action of the rollers being to bite nearly through the gutta percha and allow of the wires so covered being easily separated. These early attempts at covering with longitudinal seams proved unsatisfactory, however, the seams in many places opening, and thus exposing the conductor. This drawback has been overcome by Mr. Smith, partly in consequence of the nature of the compound, which welds much better than gutta percha, and partly because the machine which lays the tape round the wire draws it up very tightly, an operation which is rendered possible by the backing employed with the tape. Mr. Hannan, who represents the inventor in this country, is so confident of the mechanical and insulating properties of okonite that he considers it possible to utilise these cables when simply drawn through existing sewers without any protection whatever, and for indoor electric light installations to embed them in the plaster without wood beading or other protection. The tests by Dr. Hopkinson above referred to included also the measurement of inductive capacity, insulation, and the absorption of residual charge in pieces of wire not mechanically abused. The capacity was measured by charging a known length of the conductor to a known potential, and then discharging it through a ballistic galvanometer. From these measurements, and from the dimensions of the conductor and its insulation, the specific inductive capacity of the material can be deduced. It was found that the specific inductive capacity varied between 4·444 and 4·849, the mean being 4·6, which is very nearly the value generally given for gutta percha. The insulation was tested by immersing about 2,000ft. of wire in water, then charging it to a known potential, and measuring by means of a quadrant electrometer the rate at which the potential fell during a given time. Obviously the rate of loss of potential per second, multiplied by the capacity of the wire, is inversely proportional to the insulation resistance, if the latter is independent of the potential employed. This point had previously been ascertained by making the tests with 375, 50, and 3 Clark standard cells. The temperature of the conductor was assumed to be the same as that of the water of the bath, and the following table gives some of the results obtained :—

2,000ft of ·85mm. wire measuring 2·96mm. over the insulation.

Temperature in Centigrades.	Insulation Resistance per Statute Mile, in Megohms.
30·75	2,238
28·0	3,344
25·7	4,475
22·5	5,387
17·8	8,311
13·2	10,389

1,950ft. of 1·6mm. wire measuring 4·4mm. over the insulation.

Temperature in Centigrades.	Insulation Resistance per Statute Mile, in Megohms.
28·5	4,553
24·5	6,395
17·6	12,209
15·15	17,910

It will be seen that the insulation resistance decreases considerably with an increase of temperature; but even for comparatively high temperatures it is exceedingly good. The absorption of residual charge was found to be so unimportant that it need not enter into consideration in any practical application of these wires.—*Industries*

THE SUPPOSED "NEW FORCE."

BY DR. SHEITLE.

The editorial remarks in *The Electrician* of July 8th, on the supposed "new force," require some comments from me, and in making such, perhaps the better course will be for me to explain in a few brief words the theory I have long held with regard to the relations which exist between gravitation and magnetism, and the method I have adopted experimentally to test its value. By such means I hope to prove the place which radiant heat holds in relation to the phenomena observed by M. Thore.

My theory is briefly as follows :—

1. That the earth's mass is permeated by currents of ethereal matter which take two opposite directions, *i.e.*, from and to the centre of the earth.

2. That the currents which pass from the earth's centre are the more immediate outcome of the attraction of the sun and moon, each of those bodies by its axial rotation originating forces of which its own mass is the centre.

3. That the currents which take the opposite course, *i.e.*, towards the centre of the earth, are the result of the earth's axial rotation.

4. That the currents affecting the earth from either source, being dependent upon the *mass* of the earth, are equal, opposite, and imperceptible, except when they are interfered with by some impressed force.

5. That the motion of the sap in vegetable life, the motion of the blood or nutrient fluid in animal life, constitutes displacement of matter, and in common with the mechanical motion of a stone, the motion of a pendulum, a local rise of temperature, a chemical change, &c., &c., gives a new direction to the force so far as the particle moved is concerned.

It will be perceived that this theory does not differ from that now held with regard to gravitation except in one very important particular, viz., *the existence in every rotating mass of two opposite currents of highly attenuated if not absolutely ethereal matter.* That such currents do exist I believe any impartial observer will admit when the experiments which I have conducted are duly considered. Moreover, in the present state of our knowledge the cause of gravitation is declared to be altogether unknown, if not unknowable. Under my theory all mystery vanishes, for all the phenomena which pertain to the life of the universe can then be directly traced to the mode in which dissimilar forms of matter are acted upon by current forces, which permeate and sustain them in their natural condition.

The plan I have followed to test how far facts support the above theory may also be briefly stated, and is as follows :—

1. I ascertained the magnetic character of the arterial and venous blood corpuscles, and proved* that the arterial blood corpuscles are paramagnetic to the corpuscles of the blood in the venous state—a fact of no inconsiderable importance when it is recognised that the arterial corpuscles have the power of stimulating the nerves to a healthy vital action, whilst this property is entirely removed from the venous corpuscles.

2. I investigated the character of magnetic force in bar magnets,† and have proved—(A) That the equator is always oblique ; (B) That when two magnets of the same size are placed together end on, the polar line in each is removed from its previous position a little distance short of the pole end, and in the case of two magnets of equal power is found along the line of contact ; (C) That when two poles of the same size are placed near to each other, and the position of the filings which mark the central quadrangular space is carefully observed, these lines are always uneven. Phenomena 1 and 3 are suggestive of motion being established by unequal couples ; whilst No. 2 shows the readiness with which the polar forces of two magnets are displaced and converted into a single pole absolutely at the line of contact.

3. I have been conducting the experiments to which the editorial note in *The Electrician* refers with the object of showing the cause of terrestrial magnetism. I believe these experiments show : 1. That the axial and orbital motions of a planet are primarily dependent upon the mode in which the mass refracts, and then deals with currents of highly attenuated if not ethereal matter, as such matter is drawn through it by the attraction of the sun. 2. That the magnetic poles are the direct outcome of these lines of highly attenuated matter being brought to foci or points, and consequently—3. That magnetism and gravitation are only different names for the same form of motion.

With the foregoing preliminary remarks I shall now proceed to state the nature of the experiments, but in order fully to understand the significance of the phenomena evolved it is necessary that my method of investigation and the apparatus used should be fully described.

The accompanying drawing (Fig. 1) gives a good general idea of the apparatus, and may be readily understood by reference to the letters affixed to different portions. The heavy circular table T, 2ft. 6in. in diameter, is fixed to the floor by means of brass screws attached to each leg. On the upper surface is a raised inner circle 21in. in diameter and 1in. high ; round this is fitted a flat wooden ring 1in. thick, which extends to the edge of the table ; another slab of wood 23in. in diameter is tightly fixed down to the central raised portion, so forming with the lower portion a groove in which the flat ring can work easily. To one side of this ring is attached a wooden arm, U, for supporting the lamp stand and scale ; the latter extends through 90deg. on either side of the zero point, the radius being 36 inches. By means of the ring the lamp and zero point

* Vide *Proceedings* of the Royal Society, No. 157, 1875. † *Ibid*, 1879.

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of the scale can be adjusted to any part of the circumference of the table without disturbing any object which after suspension had come to rest.

Upon the upper platform of the table is a carriage for the magnet G. This is so constructed and placed upon rollers, R, that it is capable of being moved round the suspended objects, the distance from the centre being kept by a central perpendicular pivot or trunnion H, which is embraced by a projection from the carriage just named, and supplemented by another adjustment by means of which the base board of the magnet slides either to or from the centre. By this movement the magnet could be adapted to objects of various sizes.

The coil of the magnet M is placed horizontally in a wooden bracket, or clamp, which also turns upon a central pivot, enabling the axis of magnetic force to be directed to the centre, or to one or the other side of the suspended body. The coil is fixed in position by a brass cap screwed down to the wood on either side.

Accuracy with regard to the axis of magnetic force in relation to the centre of the suspended body is secured by means of six strands of fine silk, which are strained across the aperture of the coil next to the suspended body, one across the centre of the field perpendicular to the axis, and one at a distance of half an inch on either side; these strands are crossed horizontally by three other strands arranged in the same way. A movable brass cap, with central aperture of the same size as the tube in the coil, is crossed by similar strands of silk, and fitted over the other end of the coil. By this arrangement for sighting, coupled with the universal adjustment provided by the torsion head, which will be described, the filament suspending a body in the magnetic-field can be accurately adjusted so as to be in exact line with the axis of the magnet at any point of the compass. When 1in. spheres are suspended in front of the coil the outer strands of silk assist in determining accuracy of adjustment both vertically and horizontally. The torsion head H, which permits of universal adjustment, is firmly screwed to a beam, B, which is attached to the wall of the room to prevent vibrations of the floor being communicated to the suspended objects.

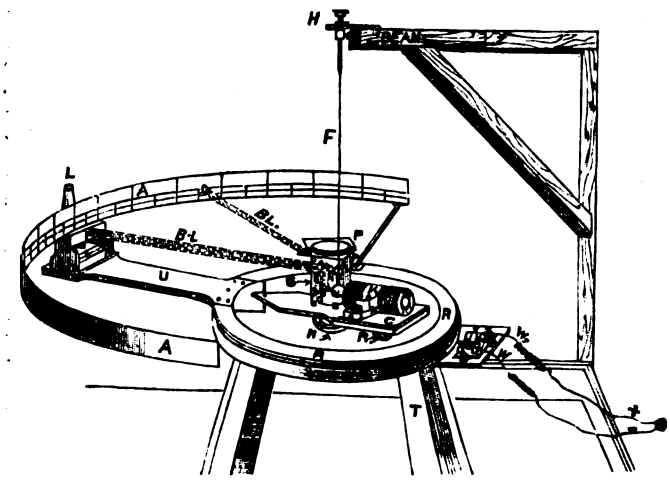

FIG. 1.

A glass cylinder, C, is placed round the suspended bodies to prevent their being affected by currents of air. This is covered with two strips of glass, between which the suspending silk passes down. The spheres, coils, or cylinders S are suspended from the bottom of the mirror rod by means of four loops of narrow silk ribbon, which are bound to the mirror rod with fine silk or cotton. These loops are only large enough to admit the spheres under pressure. The wooden mirror rod is $\frac{1}{8}$th of an inch square, and $2\frac{1}{4}$in. long, a fine copper wire hook being fixed into the upper end for receiving the suspending filament. The glass mirror is circular and fixed into a brass frame. It is capable of being readily adjusted to the mirror rod so as to reflect the light of the lamp. The suspending filaments are made of cocoon silk. Each filament is prepared for use by suspending a weight by it for several days in order to thoroughly strain it and remove twist. The battery power used in these experiments consisted of four, sometimes only three, large Grove cells, the platinums of which were 6in. by 4in.

Contact between the battery and the coil of the magnet is capable of being maintained, notwithstanding the various circular movements of the magnet and carriage, by passing the wires upwards through the table inside the wooden ring R; they are then fixed to the surface of the upper platform by means of two binding screws, from which they are carried in grooves to the bottom of two circular copper troughs to which they are soldered; these troughs surround the axis of rotation. The wires from the coil of the magnet pass downwards, and are soldered to copper rings which fit into and pass nearly to the bottom of the copper troughs. Constant contact is then maintained in any position of the magnet by the mercury with which the troughs are filled. The current is made, reversed, or broken by means of an ordinary commutator conveniently placed. Iron is entirely excluded from the whole of the apparatus upon the table, with the exception, of course, of the core of the magnet.

I believe I have now shown that when a sphere, or other body, is suspended in the glass cylinder in front of the pole of the magnet, (1) it is entirely excluded from external impressions, except such as are made upon it by the action of the electro-magnet through the glass cylinder, but (2) that it is free to move either to the right or left under such influence. I should also state that prior to testing the behaviour of any object under the influence of the magnetic pole, after suspension, it is allowed to come to a state of rest, or as near an approach to rest as can be obtained, as shown by the light on the scale. When this has occurred the zero point of the scale is moved until the light falls upon it; the magnet is then thrown into action by turning on the battery current, and the motions of the suspended objects are carefully noted.

The first object which I tested was made as follows:—A 1in. sphere was turned out of light wood and then flattened at the poles. The plane of the ecliptic was then marked, also the seat of the four magnetic and two geographical poles. Seventy-four pins were driven into the line of the ecliptic, tolerably equi-distant, and one into the seat of each magnetic and geographical pole. One thousand yards of No. ·012 single silk covered and paraffined copper wire having been procured from Elliott Brothers, the covering of the sphere was commenced by placing two strands of wire, each 7in. in length, between every pair of pins in the ecliptic line. The wires were then bent back upon themselves in the shape of the letter V, and each was wound spirally round the hemisphere upon which it was situated, the one having a right, the other a left hand turn, as shown in figure 2, so as to give them a turn and a half round each hemisphere before terminating at one of the magnetic poles, the two ends of each pair on one side of the line being carried to the seat of the two magnetic poles in that hemisphere, the other two ends to the seat of the magnetic poles in the other hemisphere, as nearly as this could be effected with the same inclination, number of strands, and number of turns to each. These windings were so made that the diagonal poles might be brought under the influence of the same wires. The object of the diagonal direction was to cause a more general disturbance of power when the spheroid was subjected to the influence of an electro-magnet.

When all the strands (148) of this layer of wires had been thus laid over the surface of the spheroid they were fixed in their situation by means of india rubber insulite. A second layer, consisting of three strands between each pair of pins, was then laid over the surface in the same manner, and fixed with insulite.

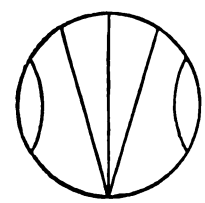

FIG. 2.

Layer after layer was thus superimposed, the number of strands between each pair of pins, as well as the length, increasing with each layer and as the sphere increased in diameter, until the whole of the 1,000 yards had been laid on. The strands of wire were doubled upon each other, and the loop at the end cut off; in this way the proper length of the strands was readily secured, the loss in the length of the wire being considered as under 20 yards. Circular bone pins were inserted in the positions of the terrestrial magnetic poles; a large rod of the same material was passed completely through the sphere; the ends of this last rod were capped with phosphor-bronze points with a view to mounting the globe in conical sockets of the same description. A frame was prepared and the globe mounted so that its axial inclination corresponded with the inclination of the earth.

Previous to mounting, the globe was covered with the same india rubber insulite as had been used in its construction. It was then pressed very accurately into the spherical form, and made to run in the sockets with as little friction as possible. The diameter of the spheroid when finished was 4 inches at the equator and $3\frac{1}{4}$ at the poles.

Experiment 1.—The first attempt to rotate this spheroid was to present it mounted as described to one of the poles of an electro-magnet laid horizontally upon the table, but no motion occurred; the same result followed when a small permanent magnet was approached to another portion of the spheroid.

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Experiment 2.—The spheroid was now removed from its frame and suspended centrally with the axis of the magnet from a wooden rod by means of several strands of cocoon silk which were attached to the north geographical pole. The surface of the sphere was ¼ of an inch from the pole of the magnet, which was flat at the end. The position taken by the north magnetic poles before battery contact was made was diagonal, as shown in Fig. 3. The circuit

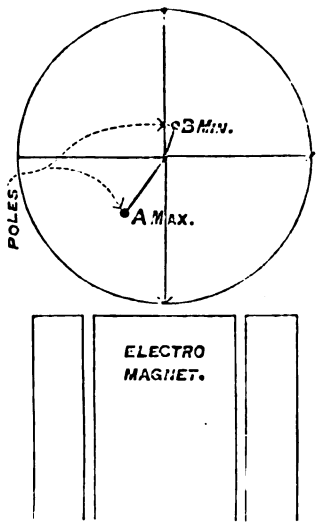

Fig. 3.

was now closed, and almost immediately axial rotation commenced, the maxim pole going from west to east through an angle of more than 90° ; it then oscillated between these two points (see Fig. 4),

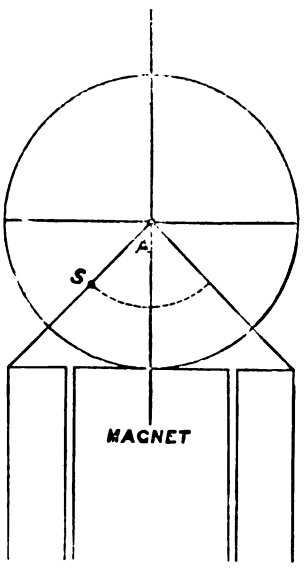

Fig. 4.

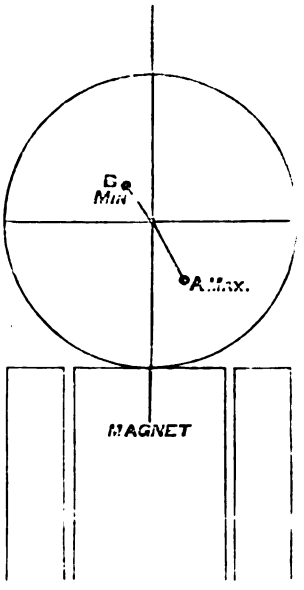

Fig. 5.

but the angle of oscillation decreased, and it finally came to rest about ¼in. to the east of centre of magnetic pole (see Fig. 5). The diameter of the iron core of the magnet was 2in.

(To be continued.)

SOUTH KENSINGTON.

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT.

(Continued from page 203.)

Frictional Electricity.

5. A pith ball is suspended from a metal stand by a fine thread. If you have a strongly electrified glass rod, how can you find out whether the thread is a conductor or a non-conductor of electricity ?

Answer. On bringing the electrified glass rod near to the suspended pith ball, the pith ball will be attracted, and if the thread be a non-conductor it will, on coming into contact with the rod, receive a charge similar to that of the rod, and will therefore be repelled ; but if the thread be a conductor, the electricity communicated to the pith ball will not be retained by it and therefore the pith ball will remain adhering to the rod.

6. If you were given a negatively electrified stick of sealing wax and two metal balls mounted on insulating supports, how would you, with this apparatus, charge the balls with opposite kinds of electricity ? How could you afterwards find out whether you had charged the balls as you intended, and whether their charges were equal or unequal ?

Answer. Place the two metal balls in contact and bring the electrified sealing wax near to one of them, as shown in Fig. 7, which

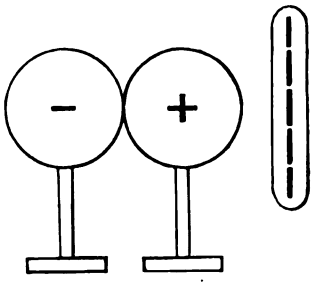

Fig. 7.

will charge them by induction as indicated. Separate the balls by means of the insulating supports before removing the sealing wax, and they will be oppositely charged.

Test them by holding them successively near to the plate of a charged electroscope, and the one whose charge is similar to that of the electroscope will cause a further divergence of the leaves, while the other will diminish their divergence.

To prove that their charges were equal, place them in contact again, and then bring each separately near to the cup of an electroscope, and in neither case will any effect be produced.

7. An insulated conductor, A, is brought near to the cap of a gold leaf electroscope which has been charged positively. State and explain what will happen (1) if A is unelectrified ; (2) if it is charged positively ; (3) if it is charged negatively.

Answer. When A is unelectrified, the leaves will slightly converge, but the effect will be hardly perceptible unless A is large.

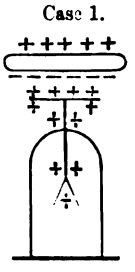

Fig. 8.

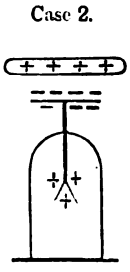

Fig. 9.

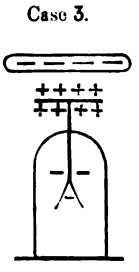

Fig. 10.

The explanation is that A becomes charged by induction, as shown in Fig. 8, and the negative electrification on the side of A near to the electroscope, acting more strongly on the electroscope than the more distant positive electrification, slightly increases the positive electrification of the plate of the electroscope, and therefore diminishes that of the leaves.

When A is electrified positively, it increases the divergence of the leaves, for it diminishes the positive electrification of the electroscope plate, and if brought near enough may even cause an induced negative electrification, as shown in Fig. 9, and therefore at the same time increases the positive electrification of the leaves.

When A is electrified negatively, the leaves will converge when A is brought near to the plate of the electroscope, and as A approaches nearer, they will fall quite together, and then begin to diverge again, for the approach of A to the electroscope increases the positive electrification of the plate, and therefore diminishes that of the leaves, and if brought near enough will ultimately give a negative induced charge to the leaves, as shown in Fig. 10.

8. Describe any experiment by which you could prove that when electrification of one kind is produced the opposite kind is also produced in equal quantity.

Answer. Rub a piece of glass and a piece of resin together, and place both of them in a deep metallic vessel resting on the plate of a charged gold leaf electroscope, as shown in Fig. 11. No effect will be produced on the electroscope, showing that there is no electrification on the outside of the vessel. Then take the pieces of glass or resin and bring them separately near to the plate of the electroscope, when one will cause a divergence and the other a

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of the scale can be adjusted to any part of the circumference of the table without disturbing any object which after suspension had come to rest.

Upon the upper platform of the table is a carriage for the magnet G. This is so constructed and placed upon rollers, R, that it is capable of being moved round the suspended objects, the distance from the centre being kept by a central perpendicular pivot or trunnion H, which is embraced by a projection from the carriage just named, and supplemented by another adjustment by means of which the base board of the magnet slides either to or from the centre. By this movement the magnet could be adapted to objects of various sizes.

The coil of the magnet M is placed horizontally in a wooden bracket, or clamp, which also turns upon a central pivot, enabling the axis of magnetic force to be directed to the centre, or to one or the other side of the suspended body. The coil is fixed in position by a brass cap screwed down to the wood on either side.

Accuracy with regard to the axis of magnetic force in relation to the centre of the suspended body is secured by means of six strands of fine silk, which are strained across the aperture of the coil next to the suspended body, one across the centre of the field perpendicular to the axis, and one at a distance of half an inch on either side; these strands are crossed horizontally by three other strands arranged in the same way. A movable brass cap, with central aperture of the same size as the tube in the coil, is crossed by similar strands of silk, and fitted over the other end of the coil. By this arrangement for sighting, coupled with the universal adjustment provided by the torsion head, which will be described, the filament suspending a body in the magnetic-field can be accurately adjusted so as to be in exact line with the axis of the magnet at any point of the compass. When 1in. spheres are suspended in front of the coil the outer strands of silk assist in determining accuracy of adjustment both vertically and horizontally. The torsion head H, which permits of universal adjustment, is firmly screwed to a beam, B, which is attached to the wall of the room to prevent vibrations of the floor being communicated to the suspended objects.

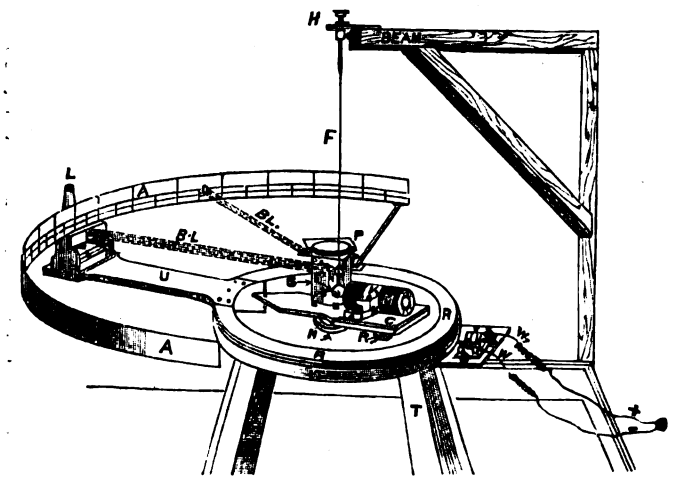

FIG. 1.

A glass cylinder, C, is placed round the suspended bodies to prevent their being affected by currents of air. This is covered with two strips of glass, between which the suspending silk passes down. The spheres, coils, or cylinders S are suspended from the bottom of the mirror rod by means of four loops of narrow silk ribbon, which are bound to the mirror rod with fine silk or cotton. These loops are only large enough to admit the spheres under pressure. The wooden mirror rod is $\frac{1}{8}$th of an inch square, and 2$\frac{1}{4}$in. long, a fine copper wire hook being fixed into the upper end for receiving the suspending filament. The glass mirror is circular and fixed into a brass frame. It is capable of being readily adjusted to the mirror rod so as to reflect the light of the lamp. The suspending filaments are made of cocoon silk. Each filament is prepared for use by suspending a weight by it for several days in order to thoroughly strain it and remove twist. The battery power used in these experiments consisted of four, sometimes only three, large Grove cells, the platinums of which were 6in. by 4in.

Contact between the battery and the coil of the magnet is capable of being maintained, notwithstanding the various circular movements of the magnet and carriage, by passing the wires upwards through the table inside the wooden ring R; they are then fixed to the surface of the upper platform by means of two binding screws, from which they are carried in grooves to the bottom of two circular copper troughs to which they are soldered; these troughs surround the axis of rotation. The wires from the coil of the magnet pass downwards, and are soldered to copper rings which fit into and pass nearly to the bottom of the copper troughs. Constant contact is then maintained in any position of the magnet by the mercury with which the troughs are filled. The current is made, reversed, or broken by means of an ordinary commutator conveniently placed. Iron is entirely excluded from the whole of the apparatus upon the table, with the exception, of course, of the core of the magnet.

I believe I have now shown that when a sphere, or other body, is suspended in the glass cylinder in front of the pole of the magnet, (1) it is entirely excluded from external impressions, except such as are made upon it by the action of the electro-magnet through the glass cylinder, but (2) that it is free to move either to the right or left under such influence. I should also state that prior to testing the behaviour of any object under the influence of the magnetic pole, after suspension, it is allowed to come to a state of rest, or as near an approach to rest as can be obtained, as shown by the light on the scale. When this has occurred the zero point of the scale is moved until the light falls upon it; the magnet is then thrown into action by turning on the battery current, and the motions of the suspended objects are carefully noted.

The first object which I tested was made as follows:—A 1in. sphere was turned out of light wood and then flattened at the poles. The plane of the ecliptic was then marked, also the seat of the four magnetic and two geographical poles. Seventy-four pins were driven into the line of the ecliptic, tolerably equi-distant, and one into the seat of each magnetic and geographical pole. One thousand yards of No. ·012 single silk covered and paraffined copper wire having been procured from Elliott Brothers, the covering of the sphere was commenced by placing two strands of wire, each 7in. in length, between every pair of pins in the ecliptic line. The wires were then bent back upon themselves in the shape of the letter V, and each was wound spirally round the hemisphere upon which it was situated, the one having a right, the other a left hand turn, as shown in figure 2, so as to give them a turn and a half round each hemisphere before terminating at one of the magnetic poles, the two ends of each pair on one side of the line being carried to the seat of the two magnetic poles in that hemisphere, the other two ends to the seat of the magnetic poles in the other hemisphere, as nearly as this could be effected with the same inclination, number of strands, and number of turns to each. These windings were so made that the diagonal poles might be brought under the influence of the same wires. The object of the diagonal direction was to cause a more general disturbance of power when the spheroid was subjected to the influence of an electro-magnet.

When all the strands (148) of this layer of wires had been thus laid over the surface of the spheroid they were fixed in their situation by means of india rubber insulite. A second layer, consisting of three strands between each pair of pins, was then laid over the surface in the same manner, and fixed with insulite.

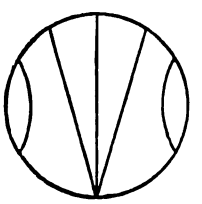

FIG. 2.

Layer after layer was thus superimposed, the number of strands between each pair of pins, as well as the length, increasing with each layer and as the sphere increased in diameter, until the whole of the 1,000 yards had been laid on. The strands of wire were doubled upon each other, and the loop at the end cut off; in this way the proper length of the strands was readily secured, the loss in the length of the wire being considered as under 20 yards. Circular bone pins were inserted in the positions of the terrestrial magnetic poles; a large rod of the same material was passed completely through the sphere; the ends of this last rod were capped with phosphor-bronze points with a view to mounting the globe in conical sockets of the same description. A frame was prepared and the globe mounted so that its axial inclination corresponded with the inclination of the earth.

Previous to mounting, the globe was covered with the same india rubber insulite as had been used in its construction. It was then pressed very accurately into the spherical form, and made to run in the sockets with as little friction as possible. The diameter of the spheroid when finished was 4 inches at the equator and 3$\frac{3}{4}$ at the poles.

Experiment 1.—The first attempt to rotate this spheroid was to present it mounted as described to one of the poles of an electro-magnet laid horizontally upon the table, but no motion occurred; the same result followed when a small permanent magnet was approached to another portion of the spheroid.

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Experiment 2.—The spheroid was now removed from its frame and suspended centrally with the axis of the magnet from a wooden rod by means of several strands of cocoon silk which were attached to the north geographical pole. The surface of the sphere was $\frac{1}{8}$ of an inch from the polo of the magnet, which was flat at the end. The position taken by the north magnetic poles before battery contact was made was diagonal, as shown in Fig. 3. The circuit

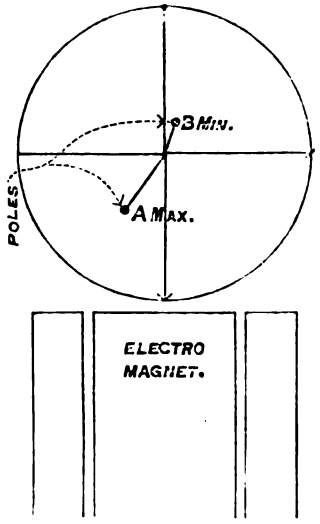

FIG. 3.

was now closed, and almost immediately axial rotation commenced, the maxim pole going from west to east through an angle of more than 90° ; it then oscillated between these two points (see Fig. 4),

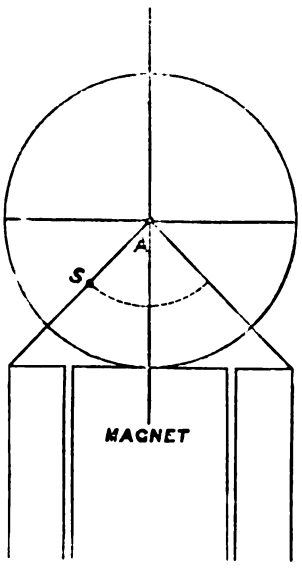

FIG. 4.

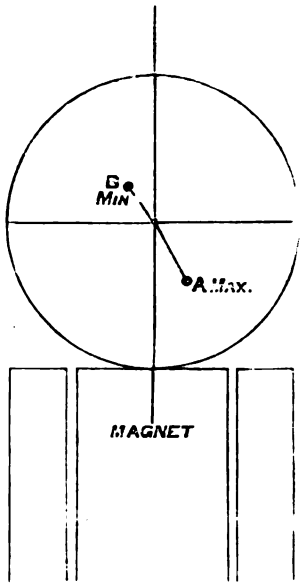

FIG. 5.

but the angle of oscillation decreased, and it finally came to rest about $\frac{1}{4}$in. to the east of centre of magnetic pole (see Fig. 5). The diameter of the iron core of the magnet was 2in.

(To be continued.)

SOUTH KENSINGTON.

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT.

(Continued from page 203.)

FRICTIONAL ELECTRICITY.

5. A pith ball is suspended from a metal stand by a fine thread. If you have a strongly electrified glass rod, how can you find out whether the thread is a conductor or a non-conductor of electricity ?

Answer. On bringing the electrified glass rod near to the suspended pith ball, the pith ball will be attracted, and if the thread be a non-conductor it will, on coming into contact with the rod, receive a charge similar to that of the rod, and will therefore be repelled ; but if the thread be a conductor, the electricity communicated to the pith ball will not be retained by it and therefore the pith ball will remain adhering to the rod.

6. If you were given a negatively electrified stick of sealing wax and two metal balls mounted on insulating supports, how would you, with this apparatus, charge the balls with opposite kinds of electricity ? How could you afterwards find out whether you had charged the balls as you intended, and whether their charges were equal or unequal ?

Answer. Place the two metal balls in contact and bring the electrified sealing wax near to one of them, as shown in Fig. 7, which

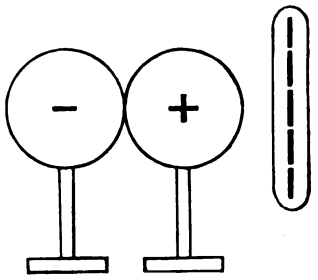

FIG. 7.

will charge them by induction as indicated. Separate the balls by means of the insulating supports before removing the sealing wax, and they will be oppositely charged.

Test them by holding them successively near to the plate of a charged electroscope, and the one whose charge is similar to that of the electroscope will cause a further divergence of the leaves, while the other will diminish their divergence.

To prove that their charges were equal, place them in contact again, and then bring each separately near to the cup of an electroscope, and in neither case will any effect be produced.

7. An insulated conductor, A, is brought near to the cap of a gold leaf electroscope which has been charged positively. State and explain what will happen (1) if A is unelectrified ; (2) if it is charged positively ; (3) if it is charged negatively.

Answer. When A is unelectrified, the leaves will slightly converge, but the effect will be hardly perceptible unless A is large.

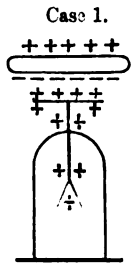

FIG. 8.

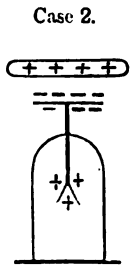

FIG. 9.

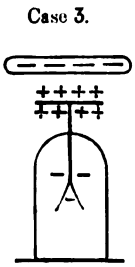

FIG. 10.

The explanation is that A becomes charged by induction, as shown in Fig. 8, and the negative electrification on the side of A near to the electroscope, acting more strongly on the electroscope than the more distant positive electrification, slightly increases the positive electrification of the plate of the electroscope, and therefore diminishes that of the leaves.

When A is electrified positively, it increases the divergence of the leaves, for it diminishes the positive electrification of the electroscope plate, and if brought near enough may even cause an induced negative electrification, as shown in Fig. 9, and therefore at the same time increases the positive electrification of the leaves.

When A is electrified negatively, the leaves will converge when A is brought near to the plate of the electroscope, and as A approaches nearer, they will fall quite together, and then begin to diverge again, for the approach of A to the electroscope increases the positive electrification of the plate, and therefore diminishes that of the leaves, and if brought near enough will ultimately give a negative induced charge to the leaves, as shown in Fig. 10.

8. Describe any experiment by which you could prove that when electrification of one kind is produced the opposite kind is also produced in equal quantity.

Answer. Rub a piece of glass and a piece of resin together, and place both of them in a deep metallic vessel resting on the plate of a charged gold leaf electroscope, as shown in Fig. 11. No effect will be produced on the electroscope, showing that there is no electrification on the outside of the vessel. Then take the pieces of glass or resin and bring them separately near to the plate of the electroscope, when one will cause a divergence and the other a

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convergence of the leaves. We conclude, therefore, the electrification of the resin is exactly equal and opposite to that of the glass.

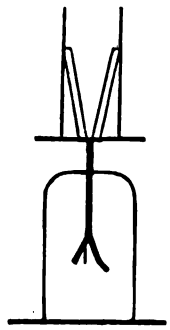

FIG. 11.

9. An orange, into which a sewing needle has been stuck, point outwards, is suspended by a dry silk thread. A charged body is brought near to it, 1st, opposite the point of the needle; 2nd, opposite the side remote from the needle. State and explain the electrical effect in each case.

Answer.—

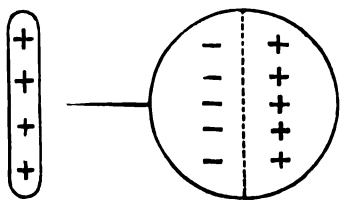

FIG. 12.—Case 1.

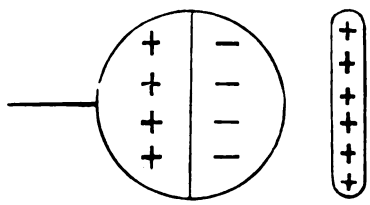

FIG 13.—Case 2.

In each case the orange will become electrified by induction, the nearer side oppositely, and the further side similarly to the electrification of the inducing body. The accumulation of electricity at the point of the needle will cause a high tension, so that in the first case opposite electricity to that of the inducing body will stream off from the point of the needle, leaving the orange charged similarly to the inducing body. In the second case, similar electricity to that of the inducing body will stream off from the point of the needle, leaving the orange charged oppositely to the inducing body.

VOLTAIC ELECTRICITY.

10. Describe and explain any workable experiment to prove that the terminals of a galvanic battery differ electrically in the same way as the conductors and rubber of an electrical machine at work, but to a less extent.

Answer.—The difference between the electrical condition of the terminals of a voltaic battery will not be sufficient to be demonstrated by means of an ordinary gold leaf electroscope, unless a condensing plate be used, as shown in Fig. 14.

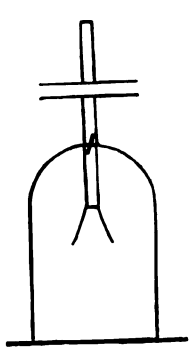

FIG. 14.

Connect the zinc terminal with one of the plates, say, the plate of the electroscope, and connect the copper with the condensing plate, and place the two plates close together without touching, as shown in the diagram, in order to increase the capacity, and therefore give a larger charge to the electroscope. While in this position remove the wires connecting the plates with the terminals of the battery, and take away the condensing plate, when a slight divergence of the leaves will take place.

Now connect the rubber of the machine with one of the plates and the conductor with the other plate, and on turning the machine gently, a much greater effect will be produced at once, without its being necessary, as in the former case, to disconnect, and separate the plates.

It follows, therefore, that the electrical difference is of the same nature in each case, but is much greater in the case of the conductor and rubber of the machine.

11. The platinum and copper plates of a Grove and a Daniell cell are connected by a wire. Would there be a current if the zinc plates were also connected, and if so in which direction would it flow?

What reason have you for your answer?

Answer. Let D (Fig. 15) represent the Daniell, and G the Grove cell.

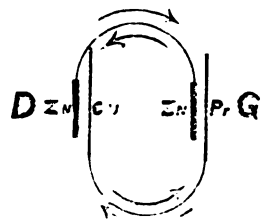

FIG. 15.

The Daniell cell will produce a current flowing in the connecting wires from copper to zinc, as shown by the small inside arrows.

The Grove cell will produce a current flowing in the wires from platinum to zinc, as shown by the larger outside arrows.

The resultant of these two currents flowing in opposite directions will be in the direction of the current due to the Grove cell, and indicated by the large arrows, because the E.M.F. of the Grove cell is greater than that of the Daniell. The strength of the resultant current will clearly be the difference of the strengths of the currents produced by the two cells respectively.

12. The current from a voltaic battery is passed at the same time through a thin wire and through dilute sulphuric acid, connected in series. What will happen to the wire and to the dilute acid; and what change (if any) will be produced in each case by reversing the battery connections, so as to alter the direction of the current through the wire and liquid?

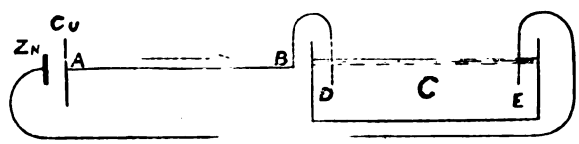

FIG. 16.

Answer. Let A B (Fig 16) be the thin wire, and C the vessel containing dilute sulphuric acid.

In the first case when the current flows from A to B

(1) The wire A B will be heated.

(2) The acid will be decomposed, oxygen being set free at the electrode D, where the current enters the liquid, and hydrogen at the electrode E, where it leaves the liquid.

(3) The acid will be heated by the passage of the current.

On reversing the battery connections so that the current may flow from B to A, hydrogen will be liberated at D, and oxygen at E, but the other effects will continue unchanged.

13. Two compass needles are arranged near each other so that both point along the same straight line. A wire connecting the platinum and zinc ends of a battery is stretched vertically half way between the needles. How will the current in the wire affect the needles, and how will the result depend upon whether the platinum terminal is connected with the upper or lower end of the wire respectively?

Answer. In Fig. 17 B is the battery and A B is the vertical wire, and the figure shows the positions of the needles when no current is passing. If the platinum terminal be connected with the upper end of the wire, and the circuit closed, a current will flow downwards from A to B along the vertical wire, and by Ampère's rule it will be seen that the two poles adjacent to the vertical wire will be deflected westward. If the platinum terminal be connected with the lower end B of the vertical wire the current will flow upwards

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from B to A, and the poles adjacent to the vertical wire will be deflected eastward.

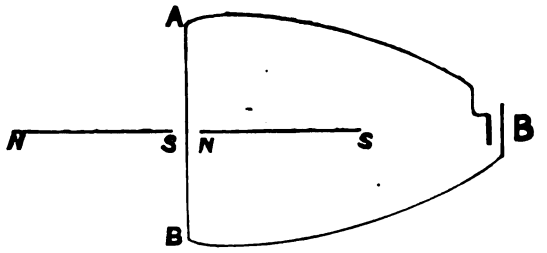

FIG. 17.

14. If you were given any galvanic cell you chose, wire with an insulating covering, and a bar of soft iron, one end of which was marked, state exactly what arrangements you would make in order to magnetise the iron so that the marked end might be a north-seeking pole? Give a diagram.

Answer. Connect the terminals of a battery by means of the insulated wire coiled into a helix, as shown in Fig. 18, and place

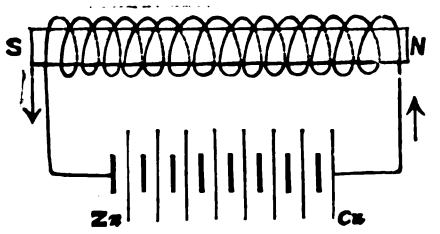

FIG. 18.

the bar of iron in the helix with its marked end at N. Then the current flowing from the copper to the zinc terminal through the helix will magnetise the bar, making the end N in the diagram a north-seeking pole.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis :—

RECHERCHES SUR LA CONDUCTIBILITE GALVANIQUE DES ELECTROLYTES.

BY SVANTÉ ARRHENIUS.

Abstract by OLIVER LODGE. *Remarks by Abstracter in square brackets.*

(*Continued from page 300.*)

§ 10.—Influence of Acid Salts.

Salts called acid are in general completely decomposed by water in sufficient quantity. According to M. Hittorf, acid phosphates are exceptions. Nevertheless, we have proved that NaH_2PO_4 is partly decomposed by great dilution (*see* Part I, § 19).

The ions of acid salts are on the one hand a metal, and on the other the rest of the molecule. If, then, one mixes sulphuric acid with, say, sulphate of soda, a portion of $NaHSO_4$ is formed. But $NaHSO_4$ behaves as any other salt, *i.e.*, its H is not an ion. So that the part of H_2SO_4 contained in $NaHSO_4$ has no effect, *i.e.*, is totally inactive. Thus equilibrating systems are set up which do not agree with calculation based upon the coefficient of activity of H_2SO_4 above given. And an equivalent of acid which forms acid salts (such as sulphuric, oxalic, &c.) cannot completely displace an equivalent of a more feeble acid from its salt, as prop. 33 asserts. [References to Berthelot.]

The calculation of the relative quantities of electrolytes contained in a system where acid salts occur goes on in the manner indicated above. Only it is necessary to observe that if the acid is τ-basic, and if an acid salt is found in which σ hydrogen atoms of the acid are replaced by a metal radical, it loses, for each equivalent of acid salt formed, τ/σ equivalents of acid. So equation (2) becomes—

$$(1-x)\left(n-\frac{\tau x}{\sigma}\right)\alpha\delta=(q+x)(p+x)\beta\gamma,$$

where n is the number of equivalents of acid added since the commencement, and 1, p, q, are the corresponding quantities for base, water, and salt.

If several salts (acid and neutral) form simultaneously, the calculation will be more complicated, as is seen most clearly by an example. Suppose one has at the beginning n. H_2SO_4 and 1. KCl; let there be formed x. K_2SO_4, y. $KHSO_4$, and some HCl; the equation (2A) will take the form—

$$(1-x-y)(n-x-2y)\alpha\delta=(x\beta+y\beta')(x+y)\gamma,$$

where α, β, β', γ, δ are the coefficients of activity of KCl, $\frac{1}{2}K_2SO_4$, $KHSO_4$, HCl, and $\frac{1}{2}H_2SO_4$, respectively.

Between x and y there is a relation which is also a function of the quantities present in the equilibrium of free acids, neutral salt, and solvent, a relation of which the form still remains to be determined by experimental methods.

§ 11. Equilibrium of Heterogeneous Systems.

[By "heterogeneous," Arrhenius means systems out of which one constituent is separated from solution in either the solid or gaseous form, and so removed from action to whatever extent it is insoluble. He quotes from Berthelot and Williamson about the formation of precipitates by double decomposition, and the continual postponement of equilibrium by the dropping out of one constituent.

He then considers a system of four bodies, I_1J_1, I_1J_2, I_2J_1, I_2J_2, of which one (say the last) is but slightly soluble. A constant quantity, c, of this remains in solution, however much of it is formed or destroyed (time being allowed for precipitate to re-dissolve *ad lib.*).

Then, α, β, γ, δ being the respective coefficients of activity, and x the amount of I_1J_2, and of I_2J_1, formed from an original one equivalent of I_1J_1 and any amount of I_2J_2 the equation (2A) is—

$$\alpha(1-x)c\delta=x^2\beta\gamma.$$

x has a magnitude depending on c, and if c happen to be zero, x vanishes.]

We have thus given an analytic proof of the laws of Berthelot.

(37) *If of four bodies,* (1,1), (1,2), (2 1), (2,2), *one of them* (2,2) *has such physical properties that it separates wholly or nearly so from the system, this body* (2,2) *and its conjugate* (1,1) *are formed, to the exclusion more or less entire of the opposite bodies,* (1,2) *and* (2,1).

If *more* than one substance is insoluble the equation may be either

$$x^2\beta\gamma=cc'\alpha\delta, \text{ or } c'x\beta\gamma=c(1-x)\alpha\delta.$$

§ 12. Consequence of the Variation of the Activity Coefficient in Homogeneous Systems.

[Since provisionally Arrhenius supposed the coefficient of activity to be identical with molecular conductivity, he goes on to consider the effect of its varying with pressure and temperature as conductivity does. Pressure variation he considers nil, or unknown. Temperature variation he considers linear, $1+bt$. So he writes (2A)—

$$(1-x)\alpha(1+b_1t)(n-x)\delta(1+b_4t)=x^2\beta(1+b_2t)\gamma(1+b_3t),$$

but then says that the b are about equal for all salts and for all bases, and fairly equal for all monobasic acids; so the temperature terms cancel each other in pairs nearly; and he states the laws.]

(38) *The equilibrium of a homogeneous system is independent of pressure.*

(39) *The relative quantities of four bodies like two acids* and two salts, or two bases and two salts, or four salts, in a system in equilibrium only vary very slightly with temperature.*

The first is in accord with Bunsen and Berthelot: the second with Ostwald, who has verified it between 20° and 100° for HCl, HNO, and two salts of these acids with a single base. He has further shown that these two acids have the same activity between these temperatures by letting them act on calcic oxalate.†

M. Ostwald has also determined the relative coefficients of affinity of different acids with regard to the same base.

He let two acids act simultaneously on a given base—as, for example, KHO, MgO, &c. The acids employed were HCl, HNO, and H_2SO_4. The term "relative coefficient of affinity" expresses the ratio between the fractions of the base which the two acids seize. If one mixes KNO_3 with HCl, one equivalent of each, there will be formed x equivalent of KCl and x of HNO_3, and there will remain $(1-x)$ equivalents of KNO_3 and of HCl. The coefficients of activity being β, γ, α, δ, respectively, x is given by the equation—

$$(1-x)^2\alpha\delta=x^2\beta\gamma,$$

and so the relative coefficient of affinity of HCl : HNO_3 is—

$$Q=\frac{x}{1-x}=\sqrt{\left(\frac{\alpha\delta}{\beta\gamma}\right)}.$$

If instead of potassium one uses sodium, γ and δ remain, but α and β change. Q, however, need not change unless α'/β' is different from α/β. (It acid salts are formed a modification is necessary.)

Molecular conductivities given above (§ 5) make one suspect that changing a base from KHO to ZnO or MgO will diminish the value of Q for $HNO_3 : H_2SO_4$ and for HCl : H_2SO_4.

For the rest, because the activity coefficients of HNO_3 and HCl are about equal, and the same for salts formed from these acids, their relative coefficient of affinity ought to be nearly 1, whatever the base on which they are allowed to act.

Here are Oswald's numbers :—

Table of Relative Affinities.

Base.	$2HNO_3 : H_2SO_4$	$2HCl : H_2SO_4$	$HCl : HNO_3$
OK	2·00	1·94	·97
Na	2·00	1·92	·96
NH_4	1·88	1·81	·96
Mg	1·76	1·74	·99
Zn	1·61	1·53	·95
Cu	1·44	1·40	·97

* Except H_2SO_4 and H_3PO_4.

† Ostwald, *Journal für praktische Chemie* (1877), T. 16, p. 385.

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In a word, we believe experiment has verified the following rule deduced from the present theory :—

(40) *If an acid HR reacts on a salt MR¹, and if α and β are the activity coefficients of the salts MR¹ and MR, the coefficients of relative affinity between the acids HR and HR¹ vary almost proportionally to the square root of the quotient α/β.*

In the first part, § 13, we remarked that the molecular conductivities of different salts approach each other in such a way that they would seem for extreme attenuation to advance towards a common limit. It follows that the quotient α/β approaches more and more to unity, and that the different values of α/β become equal.

This is why *the relative affinity Q becomes more and more constant as dilution increases*—a relation Ostwald thinks he has already perceived with dilutions less extreme.

The activity coefficients of acids and bases also approach equality as dilution increases.

(41) *Consequently the coefficients of relative affinity of acids approach more and more to unity as dilution increases.*

M. Ostwald has also on this subject made some measurements which confirm the justness of the above proposition. His researches on the magnitude of the co-efficient of relative affinity of H_2SO_4 indicate that at extreme dilutions this coefficient is "almost equal to that of HNO_3, at least it rises to ·9" (that of HNO_3 being 1), while at moderate dilutions it is ·5 or less.

To the invariability of Q for acids and bases M. Ostwald adds a fact of great importance. The molecular conductivities of feeble acids and bases increase very rapidly with dilution, *i.e.*, δ^1 (for weak solution) is much bigger than δ (for strong), so Q increases also if we compare them with strong acids and bases which are nearly unaffected by addition of water, for—

$$Q = \sqrt{\frac{\alpha\,\delta}{\beta\,\gamma}} \text{ for small dilution,}$$

$$Q^1 = \sqrt{\frac{\alpha\,\delta^1}{\beta\,\gamma}} \text{ for large dilution.}$$

Hence—

(42) *The relative affinities of feeble acids and bases (compared with a strong acid or a strong base) increase considerably as dilution goes on increasing.*

This is the reason for not attributing to these "coefficients of relative affinity," or "*avidities*," as M. Thomsen calls them, a too great importance. By believing them constant one seems to have inclined strongly towards regarding them as fundamental numbers. Also the determinations of them by different workers do not agree well with each other.

(43) *As the activity coefficients of different acids change a little unequally with temperature, the relative affinity of two acids ought also to vary with temperature.*

Thus the activity coefficient of H_2SO_4 increases more slowly than that of monobasic acids (HCl or HNO_3), whence it evidently results that its affinity relative to either of these acids diminishes as the temperature rises. We can give only a rough calculation. The temperature coefficient of conductivity for HCl or HNO_3 exceeds by 4 per cent. that of H_2SO_4 at 20° C.; so Q, which is proportional to square root of conductivity, will vary by about 2 per cent. per degree at this temperature.

The temperature coefficient for H_2SO_4 is still less at higher temperature, so its relative affinity ought to diminish faster at these temperatures. Experience agrees with this as well as one can expect.

M. Ostwald has found the following figures for the relative affinity of HCl to H_2SO_4:—

At 0° C. Q = 1·90	At 40° C. Q = 2 02
,, 20° C. Q = 2·00	,, 60° C. Q = 2·37

Between 0° and 40° Q varies about ·15 per cent. per degree, while rough calculation indicated ·2 per cent.; at higher temperatures the variation is greater, as expected. On the other hand, for HCl : HNO_3, Q is almost constant, only varying from 1·00 to 1·02 between 0° and 60°.

A great part of the cited observations (those on H_2SO_4) have been explained by Ostwald as due to the formation of acid salts at moderate dilution. We do not wish to deny this as a *vera causa*. We have already in § 10 shown that the coefficient of activity diminishes for this reason. So naturally Q diminishes too. Nevertheless, it is difficult to explain thus the variation of Q with temperature. It seems much more reasonable to admit the explanation given above.

Finally, we will consider what ought to happen to a salt solution if its temperature rise. For this it is necessary to observe that the temperature coefficient of a concentrated hydrate is much greater than that of a weak solution. Thus, according to M. Kohlrausch*—

For sulphuric acid	at 99·4	per cent.	concentration	b = ·0426
,,	,, 7·73	,,	,,	b = ·0121
For phosphoric acid	,, 87·1	,,	,,	b = ·0374
,,	,, 4·92	,,	,,	b = ·0099
For tartaric acid	,, 49·53	,,	,,	b = ·0263
,,	,, 4·95	,,	,,	b = ·0186
For caustic potash	,, 41·7	,,	,,	b = ·0282
,,	,, 4·19	,,	,,	b = ·0188
For soda	,, 42·72	,,	,,	b = ·0710
,,	,, 2·61	,,	,,	b = ·0195
For ammonia	,, 16·15	,,	,,	b = ·0303
,,	,, 0·1	,,	,,	b = ·0247

As this rule is without known exception, it seems permissible to attribute to water, which is also a hydrate, a coefficient much surpassing the coefficients of dilute compounds (which latter coefficients are almost equal among themseves). Some figures of Ayrton and Perry (*Proc. Phys. Soc.*, II. 178 [1877]) tend to confirm this. Similarly, the coefficient of a salt solution is sensibly greater than that of a hydrate. Looking, then, at the equation of equilibrium of a saline solution—

$$(p+x)\,x\,\alpha\,\delta\,(1+b_1\,t)\,(1+b_4\,t) = (1-x)^2\,\beta\,\gamma\,(1+b_2\,t)\,(1+b_3\,t),$$

we see that b_1 and b_4 are bigger than b_2 and b_3, and therefore that the value of $1-x$ obtained from it will increase with t. But $(1-x)$ signifies the amount of salt decomposed, so—

(44) *The quantity of salt decomposed in a solution is increased if the temperature of the solution rises.*

This will be true also for other electrolytic solvents, according to the law of Hittorf (see § 4). One imagines this important law can be otherwise deduced from a certain dissociation of salt molecules. True, physics show that at high temperatures the movements of molecules are more vigorous. But this does not point out why water then attacks salts more strongly. One often slurs over these difficulties by saying that heating (as well as dilution) brings to the solution a foreign energy opposed to the chemical reactions. But what, then, is the import of chemical laws if they can be annulled by causes which never disappear completely, and of which one does not know how to calculate the effect?

The above law is so generally adopted and verified by a crowd of cases so enormous that it is not necessary to cite any of them.

(To be continued.)

* *Pogg. Ann.*, T. 159, p. 233; and *Wied. Ann.*, T. 6, p. 1 (1876 and 1879).

CITY NOTES, &c.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 15th Aug., are £1,998, as compared with £1,676 in the corresponding period of 1886.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug 17.		Business Done Week Ending Aug. 17. Highest.	Lowest.
Anglo-American	36½,	37½	36¾	36
Do. Preferred	59,	60	60	59½
Do. Deferred	14½,	15½	—	—
Brazilian Submarine	11⅜,	11⅝	11⅝	11⅜
Cuba	12,	12½	—	—
Do. Preference	18,	19	—	—
Direct Spanish	2½,	3	—	—
Do. Preference	7½,	8½	—	—
Direct United States Cable	8¾,	9	9	—
Eastern Telegraph	11,	11½	11½	11 1-16
Do. 6 per Cent. Preference	14,	14½	14½	—
Do. 5 per Cent. Debentures, 1899	105,	108	106½	—
Eastern Extension	11⅞,	12	12	11⅝
German Union	10½,	11	—	—
Globe Telegraph and Trust	5½,	5½	5½	5 5-16
Do. Preference	13,	13½	13½	13
Great Northern	13½,	14	—	—
Indo-European	35,	37	35⅜	—
Reuter's	7½,	7¾	7⅝	—
Submarine	170,	180	174	—
West India and Panama	⅝,	¾	—	—
Do. 1st Preference	9,	9½	9	—
Western Brazilian	8,	8½	8 3-16	—
Western Union 7 per Cent. 1st Mortgage	120,	125	122	—
Do. 6 per Cent. Sterling Bonds	104,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16,	13-16	—	—
Oriental	½,	⅝	5-16	—
United Telephone	11⅞,	12½	12	—
United River Plate	4¾,	5¼	—	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—	—
Do. (fully paid)	3,	4	3½	—
Swan	1½,	1¾	—	—
Maxim Weston	⅜,	½	—	—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	36¾	36
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	23	

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NOTES.

GOOLE.—Tenders are asked for lighting the town of Goole "by gas or otherwise." Information may be obtained from the local authorities.

TECHNICAL EDUCATION.—The Government have definitely abandoned—for the present Session, at all events—their Technical Education Bill.

GLOBULAR LIGHTNING.—During the recent thunderstorms, it is reported that a discharge of globular lightning was observed at Camden Town.

LIVERPOOL.—Messrs. R. W. Preston and Co., a large firm of distillers, have adopted the electric light for their extensive premises at Bankhall. The installation was designed and carried out by Mr. T. M. Bigley, C.E., of Liverpool.

SALE OF ELECTRO-PLATING PLANT.—In our advertising columns particulars will be found of a forthcoming sale of electro-plating and metallurgical plant at Charlotte-street, Blackfriars-road, S.E. The auctioneers are Messrs. Wheatley Kirk, Price and Goulty.

CURIOUS.—By some singular coincidence the greater part of the *Daily News* telegrams "from our own correspondent" which described at length the lighting of the Vienna Opera appeared several weeks previously as an article (presumably an original one) in our esteemed contemporary, *Industries*.

THE PELTIER EFFECT.—At a recent meeting of the Royal Society of Edinburgh Prof. Tait communicated a paper by Mr. Albert Campbell on the direct measurement of the Peltier effect. Mr. Campbell has experimented with three pairs of metals. His results agree in every case with Prof. Tait's thermo-electric diagram.

IMPROVED CARBONS.—It is stated that in the course of some investigations, conducted with a view to obtaining some material which shall be superior to carbon for electric lighting, M. Clingmann has recently experimented with zirconium with considerable success. Pencils of this material will, it is said, last for several months in an arc lamp.

TENDERS WANTED FOR TELEPHONE CABLES.—The *Official Gazette* of Madrid, of the 20th inst., contains an advertisement from the Ministry of the Interior asking for tenders for telephone cables. The amount required is 14,000 metres of fourteen conductors, and 30,000 metres of double conductor. Tenders will be opened on the 19th September.

PRIZE OFFERED FOR A PRIMARY BATTERY.—In connection with the Petroleum Exhibition which is to be held at St. Petersburg in the ensuing winter, the Russian Ministry of War offers a prize of 500 roubles "for a compact and practical galvanic battery for electric lighting with incandescent lamps." A prize of similar amount is offered somewhat indefinitely "for phosphorescent materials and articles."

CITY AND GUILDS OF LONDON TECHNOLOGICAL EXAMINATIONS.—At the late examinations for electric lighting and transmission of power and telegraphy, we observe that the first and the second places in the honours examinations were taken by G. L. F. Phillips and Charles Yeaman respectively, and the second place in telegraphy by Maynard Dodd, all students from Prof. Jamieson's and Mr. Livingstone's classes, at the Glasgow College of Science and Arts. Three others took first class honours.

THE INSTITUTE OF CIVIL ENGINEERS.—The Institute of Civil Engineers has just issued its annual list of the subjects upon which papers are invited. Amongst these the following deal with electrical matters:—"Electro-Motors; their Theory, Construction, Efficiency, and Power." "The Construction and Maintenance of Secondary Batteries." "The Distribution of Electricity for the Lighting of Towns." "The Application of Electricity to the Working of Street Tramways." "The Application of Electricity to Smelting and Metallurgical Operations."

ARC LIGHT PROJECTORS IN THE ROYAL NAVY.—We should like to know whether any good reason can be assigned for the preference shown by the Admiralty for hand regulation of the carbons in projectors. It is difficult to see that any possible advantage is to be gained by giving the blue-jacket who directs the beam a double duty to perform, and the Admiralty must surely be aware that automatic regulation is a very simple affair. In the late naval manœuvres the unsteadiness and coloration of the beams, owing to defective adjustment, was often observable.

"ELECTRICAL PLANT."—We observe with pleasure that Messrs. Wheatley Kirk, Price and Goulty's new trade list meets with continued success, at least so far as the number of advertisements is concerned. As to circulation, a free issue of 1,000 is guaranteed, but the actual number distributed considerably exceeds this figure. We would venture to make one small suggestion calculated to increase the usefulness of the publication, namely, that plant of all descriptions which is available for hire as well as purchase should be indicated throughout by an asterisk.

MOTORS IN THE STATES.—According to the New York *Electrical World* the number of electric motors now running in the States may be taken at about 10,000. We doubt whether in this country the number in actual use exceeds 400 or 500. In America one company alone has sold over 2,000 motors, while another has built 2,500 *since last November*. It was at first supposed that the demand would be chiefly for machines of 5 horse-power and under, but it is found that the demand is brisk up to 10 and 15 horse-power. The larger sizes are chiefly used for printing machinery.

TRANSMISSION OF ENERGY IN NEW ZEALAND.—In a handbook recently issued by the New Zealand Government and devoted to a description of the mineral resources of that country, there is a detailed description of the electrical transmission of energy which is employed for working the stampers at the Phœnix Gold Mines, Upper Shotora, Otago. Power is derived from a waterfall at a distance of 2½ miles. We gave a full description of this installation some twelve months ago, and are glad to hear of its continued successful working. It may be remembered that the plant was supplied by the Anglo-American Brush Co., and consists of a pair of Victoria dynamos.

MR. ELLIS LEVER'S PREMIUMS.—In addition to the renewed offer of £500 for an electric safety lamp, Mr. Ellis Lever has decided to repeat his offer of £500 for a perfectly safe, practical, and efficient means of blasting without gunpowder. He has communicated his intention to the Home Secretary; and on the condition that the Government will undertake the necessary tests and make the awards, he has offered to place in Mr. Matthews' hands £1,000, to be awarded in two premiums of £500 each—one for the best method of safe blasting in coal mines without the use of gunpowder, and the other for a safe system of electric lighting in mines to supersede the present so-called safety lamp.

WHITWORTH SCHOLARSHIPS FOR 1887.—The results of the examinations for Sir Joseph Whitworth's Scholarships in Mechanical Engineering Science have just been sent to the successful candidates, and we have again to intimate the more than usual success of Glasgow students. This year 25 scholar-

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ships have been awarded, one of £200, eight of £150, and sixteen of £100. On the whole, with the exception of Glasgow, these scholarships are pretty well distributed throughout the United Kingdom. The first scholarship of £200 has been awarded to a Mr. Whitaker, of Burnley. Six scholarships have been taken by Glasgow men, and of these the first five, of a value of £150 each, fall to students trained at the Glasgow College of Science and Arts, making a total of 17 Whitworths taken by this Institution in four years (£2,300).

M. Menges' Electrical Governor.—In another column will be found a letter from M. Menges, in which he takes some exception to a note in our last issue, refering to his electrical governor. We had before us at the time a very enthusiatically-written article in one of our French contemporaries, in which the elementary notion of an electrical governor was spoken of as something entirely new and worthy of the highest admiration. The details were not very clearly given, but so far as they could be gathered the description certainly justified us in speaking of the idea as being put into operation "in a somewhat crude form." However, we shall hope very shortly to place our readers in a position to judge for themselves as to the merit of the device, of which now that we have a description at first hand it is possible to speak in very different terms.

University College, Dundee.—We have received a copy of the calendar for the fifth session of the University College, Dundee, and are pleased to note the continued success and enlarged scope of the operations of this institution. The college was founded in 1880, chiefly by the munificence of Miss Baxter, of Balgarris, who at different times has contributed to the foundation and endowment funds no less than £140,000. By the deeds, the trustees are directed to apply the means put in their hands "to founding, establishing, endowing, maintaining, and conducting a college for promoting the education of persons of both sexes, and the study of Science, Literature, and the Fine Arts." As regards the subjects in which we are most interested, the names of the professors who occupy the principal chairs are a sufficient index of the rank which the Dundee College occupies in the teaching of science. The chair of Engineering is filled by Prof. J. A. Ewing, F.R.S.; Chemistry is taken by Prof. J. Carnelley; and Mathematics and Natural Philosophy by Prof. J. E. A. Steggall.

The Telegraph in Japan.—The progress of telegraphic enterprise in Japan and the neighbouring countries is strikingly shown by the figures quoted in Consul Sir F. R. Plunkett's report from Nagasaki. The inland (Japanese) messages passing through Nagasaki last year numbered 201,979, against 142,250 in the preceding year. The foreign messages (outward) were 17,501, against 15,134 in 1885; inward 17,322, against 15,874 in 1885. The great increase in the number of international messages in the last eight years —in 1878 the total was under 3,600—is due to the development of the Chinese telegraph system, especially in those ports which have steam communication with Nagasaki, and to its extension from the Chinese frontier to Chemulpo and Söul in Corea. A still further increase may be looked for on the completion of the land line connecting Söul with Fusan, and telegrams will then be transmitted by the Nagasaki and Fusan cable instead of passing over the Chinese system. This line is expected to be in working order before the end of the present year.

Tests of Electrical Instruments at the Antwerp Exhibition.—The publication of the result of the tests of electrical instruments and apparatus made at the Antwerp Exhibition of 1885 has been long delayed, but we learn that it will now make its appearance very shortly. According to our contemporary, *l'Electricien*, the result of the examination of two types of industrial ammeters and voltmeters in most frequent use has not been very satisfactory. In some cases the error has exceeded 7 per cent.; this is the more unsatisfactory as it may be supposed that the instruments sent for trial were calibrated with special care, and are scarcely likely to have received much rough usage. Our contemporary refers also to the Ferranti coulomb-meter, the constant of which instrument (the figure representing the number of turns per hour corresponding to one ampere) was found to increase with the current. For instance, at 7 amperes the constant was 608, at 14·7 amperes 662, and at 22·7 amperes 697. We believe, however, that Mr. Ferranti has succeeded in remedying this serious defect in later types of his instrument.

Some Belgian Tenders.—Tenders were recently asked for an installation of 400 16 candle-power lamps in a new military hospital in this city. Two engines, each of twenty-five indicated horse-power, with separate boilers and accessories, were to be provided. The Société Phœnix-Edison, of Ghent, tendered for 69,000 francs, and the Société Electricité et Hydraulique, of Charleroi, tendered for 67,000 francs.—For the lighting of the Schaerbeek Railway Station, for which no exact specification was issued, the following tenders were received:—(1) M. Schuckert, twenty-four arcs of 600 candle-power, at the rate of 0·52 franc per lamp-hour for the first 3,000 hours guaranteed, 0·45 franc for the next 500 hours, and 0 40 franc for the remainder. Estimated cost of plant 114,512 francs, of which the State should pay 38,000 francs on terminating the contract. (2) La Société d'Eclairage du Centre; (*a*) 11 arcs of 1,100 candles (mean spherical intensity) at the rate of 0·67 franc for the first 3,000 hours guaranteed, 0·55 franc for the next 500 hours, 0·45 franc for the remainder. Estimated cost, 57,500 francs, of which the State should pay 18,500 at the end of the tenth year. (*b*) Sixteen arcs of 900 candle-power at the rate of 0·54 franc for the first 3,000 hours guaranteed, 0·45 franc for the next 500 hours, and 0·35 franc for the remainder. Estimated cost, 65,500 francs; 24,500 francs to become payable at the end of the tenth year.

Long Distance Telephony in the States.—The telephone line between New York and Philadelphia, which was opened for the public service in January last, has proved quite successful in operation, although a good deal more work could be got out of it than is yet required. It may perhaps be remembered that the line consists of no less than fifty wires—twenty-five circuits—of hard drawn copper wire. At present the communications amount to between 150 and 250 a day, while a steady increase is perceptible. The tariff is $1 for five minutes, no charge being made if the person inquired for is not found. In New York there are 130 private firms in direct communication with the Philadelphia line independently of the local exchange, and in Philadelphia there are 40 similar connections. The number is smaller at Philadelphia, because the company has put up instruments at the chief hotels for public use. In starting with as many as twenty-five circuits the idea entertained was that many of them could be leased outright to private firms or corporations. This has been done to a certain extent, and other wires are jointly rented by a number of firms. Several smaller towns upon the road have recently been placed upon the circuit. The success of the company has been sufficiently marked to induce them to extend their operations. Thirteen circuits are already at work to New Haven, and lines are in progress from New York to Boston, Albany, Washington, and several smaller towns.

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MUTUAL INDUCTION COEFFICIENTS.—It is well known that when two coils wound upon the same iron core with coefficients of self-induction L_1 and L_2, the maximum possible value of their coefficient of mutual induction is equal to $\sqrt{L_1 L_2}$. This value of M is obtained on the assumption that each coil is traversed by the whole of the lines belonging to the other coil, a condition which is most nearly fulfilled when the two coils are wound upon a closed iron core, especially if the whole of the surface is covered by each coil. The *Electrotechnische Zeitschrift* has recently published the result of some experiments on various coils with a view of determining the difference between the observed and calculated maximum of M. This table we reproduce below, and it will be observed that the difference is very small. It is, however, obvious that the experiments are not of much practical value unless accompanied by information as to the size, shape, and structure of the coils. The question is, in fact, merely one of magnetic leakage.

	Resistance.		Number of Turns.		L_1.	L_2.	M.	$\sqrt{L_1 L_2}$.
	Primary.	Secondary.	Primary.	Secondary.				
1	0·4	234	160	7980	0·0012	0 60	0·026	0·0268
2	2 2	680	435	4400	0·0073	0·71	0·067	0·072
3	281	281	...	...	0·22	0·22	0·219	0·22
4	1007	1118	5998	5998	1·015	4·015	1·000	1·015

PROPOSED ELECTRIC TRAMWAY FOR LEEDS.—On Tuesday the Leeds Town Council discussed several projects for constructing a railway or tramway from the heart of Leeds to Roundhay Park, with the view of making that pleasure resort more available to the public. Mr. Lupton informed the Council that at his request Mr. M. Holroyd Smith, electrical engineer, of Halifax, was present, and, if allowed, would explain his scheme for the construction of an electrical railway.—Mr. Smith said that it was quite within his experience to be able to make a line from the centre of the town to Roundhay Park, and back again, to work it by electricity, with more safety and more regularity, and at a lower rate than it could be worked by any other means. It was the best power for meeting an exceptional increase in the quantity of traffic. On the line at Blackpool the number of passengers carried during six days in the winter was 2,393, and the cost for fuel and wages was under £24; but in September, 1886, during the height of the season, the number of persons carried over a distance of two miles in the same period was 44,306, while the cost for wages and fuel was only increased to £45. He was quite prepared, whether a tramway line was made a subway line or an overhead line, to be at the cost of all the electrical working of that line, and would guarantee that he did it at a less cost per mile than could be undertaken by any other system. In answer to questions, Mr. Smith said that he had undertaken to work cars up a gradient of 1 in 8, and that there would be less difficulty in working a railway than a tramway. The Council took no definite action at the meeting, but an opinion was strongly expressed in favour of some scheme which would not require the use of the public roads.

THE THUNDERSTORMS.—At the close of last week further thunderstorms were reported from various parts of the country. At Rawmarsh, near Rotherham, a collier named Charles Thompson was killed by lightning. He and another collier named George Grey left the pit to return home, and, being overtaken by the storm, sought shelter under an oak tree in the middle of a lane. A flash of lightning struck the tree, passed down its trunk, and struck the two men beneath it. Thompson was killed on the spot, having been struck on the head, and his clothes were torn and the buttons melted off. Grey was badly injured, and is not likely to recover. A West Riding policeman was taking shelter from the rain against a wall in the yard, when he was struck and rendered insensible. Much damage was done in Brimington, a village about two miles from Chesterfield. Four houses were struck, and one suffered terribly. The lightning, it appears, attacked the end of the building, passed on to the front of the house and entered the sitting room, carrying with it the window frame and glass and smashing to atoms all the furniture. The roof was left without a single slate, only about a couple of copings remaining, and these were midway between the roof and square of the building. The windows throughout the whole house were blown out, the sash weights and fire grate being piled up in a corner of the top front bed room, and the cupboards presented the appearance of a pottery scrap heap. The roof of an adjoining house was partly taken away. The clock chain was melted as if it had been in a furnace. The other houses were more or less seriously damaged, the walls being dislodged several inches. No lives, however, were lost.—An inquest was held at Birmingham recently on the bodies of the two men, Lockyer and Stainer, who were killed by lightning at the Atlas Brickworks during the storm of Wednesday week. The men had taken shelter in a hut when the chimney stack, 140ft. high, was struck by lightning; the discharge passed through the hut and killed the two men. There was a mark of scorching on the back of Lockyer's right leg, the hair on the right side of both was singed, and there was a mark like an impression of a tree on the chest of each man. A verdict in accordance with the evidence was given, and it was recommended that a lightning conductor should be attached to the stack. Some curious and terrible effects of lightning are reported from Mende. During the recent thunderstorms in that locality the room of a Madame Gaillard was suddenly illuminated with the flashes of fire. The woman and her three children, frightened out of their wits, ran for safety to the chimney corner, when a single sharp clap of thunder was heard over the house, and the chimney was struck by lightning. The mother and the three children were knocked down insensible. One of them, a boy of four, was killed instantaneously; and a little girl was whirled into the centre of the room, and had her eyes completely burned out.

THE BRITISH ASSOCIATION MEETING.—The following is the programme of the forthcoming meeting of the British Association at Manchester, over which Sir Henry Roscoe will preside:—Wednesday, August 31st: President's address, in the Free Trade Hall, at 8 p.m. Thursday, September 1st: Sectional meetings, 11 a.m. to 3 p.m.; *Conversazione* at the Royal Jubilee Exhibition. Friday, September 2nd: Sectional meetings, 11 a.m. to 3 p.m.; Lecture by Prof. H. B. Dixon, M.A., F.R.S., on "The Rate of Explosions in Gases," in the Free Trade Hall, at 8:30 p.m. Saturday, September 3rd: Sectional meetings, 11 a.m. to 1 p.m.; Excursions; Lecture to working men, by Prof. George Forbes, F.R.S., on "Electric Lighting," in the Free Trade Hall, at 8 p.m. Monday, September 5th: Sectional meetings, 11 a.m. to 3 p.m.; Lecture by Colonel Sir Francis de Winton, K.C.M.G., R.A., F.R.G.S., on "Explorations in Central Africa," in the Free Trade Hall, at 8:30 p.m. Tuesday, September 6th: Sectional meetings, 11 a.m. to 3 p.m.; *Conversazione* at the Town Hall. Wednesday, September 7th: General meeting in the Chemistry Lecture Theatre of Owens College, at 2:30 p.m. Thursday, September 8th: Excursions. In Section A (Mathematics and Physics) the presidential chair will be occupied by Sir Robert S. Ball, the Astronomer Royal of Dublin, who is expected to discourse on "The Theory of Screws." Sir Robert has the

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reputation of a wit, and his address is looked forward to with considerable interest. We have, indeed, heard it rumoured that the subject will be treated in its broadest aspect (including the human species), and that there will afterwards be a practical demonstration of the theory of cork screws. Some of the most serious and important work of this section will be done in connection with the theory of electrolysis, to the report on which subject our readers are aware Prof. Oliver Lodge has devoted himself with unremitting energy during the last twelve months. The discussion will probably be held on Saturday, and on this occasion the chemical and physical sections will unite. It is also anticipated that some important experimental results in electrolysis will come from Owens College. If time permit it is intended to have a discussion on the report of the committee on the vexed question of electrical standards. Mr. Preece will read a paper on the specific resistance of commercial iron wire, and another on the coefficient of self-induction of telegraph wires, and on the induction between wires and wires. The result of the new magnetic survey undertaken by Profs. Thorpe and Rücker will be communicated, and Mr. Haldane Gee will exhibit a comparison magnetometer. In the section of Mechanical Science, where Prof. Osborne Reynolds occupies the chair, Mr. Gisbert Kapp will read an interesting and important paper "On the Condition of Maximum Output by Alternating Current Dynamos." The paper will also contain the results of an investigation of the conditions for obtaining maximum work from a series-wound motor supplied with an alternating current.

THE LIGHTING OF THE VIENNA OPERA.—The electric lighting of the Vienna Opera, which has recently created so much attention on the part of the non-technical press, is really a noteworthy affair, inasmuch as it constitutes beyond all comparison the most extensive, and in some respects the most severe, test to which secondary batteries of recent design have as yet been put. The cells, 1,296 in number, were supplied by the Electrical Power Storage Company. They each contain 31 plates, and the total weight of plates alone is approximately 100 tons. The boxes, which are of glass, are erected on stands, six tiers high, each cell resting on a separate tray supported by oil insulators. The accumulator is subdivided into twelve batteries, each consisting of 54 elements of 2 cells in parallel; during charge the accumulator is arranged in 4 series sets of 3 of the batteries coupled in parallel, thus practically forming the total of 218 elements of 6 cells in parallel, and requiring a charging electromotive force of 540 volts at the battery terminals and a current of 360 amperes. The discharging capacity is 144,000 watts, or, in other words, 2,440 sixty-watt 100-volt lamps can be supplied without the aid of the machinery for nine hours. The cells have been put together and erected by the Electrical Power Storage Company's staff at Vienna, the contract for accumulators having been received direct by that company from the Imperial Continental Gas Association. The whole of the remaining work, including the supply and erection of engines and dynamos, was entrusted by the Imperial Continental Gas Association to Messrs. Crompton and Co., who have supplied five of their own machines, coupled direct to Willans engines. The engine plant is placed in a large building, formerly occupied by the British Embassy, at a considerable distance from the theatre. Each dynamo is wound for a current of 120 amperes at 600 volts, the armatures being 36in. in length, the fields are separately excited, and the engines are supplied with Willans electric governors, the regulation being for constant current. The engines are single acting compound, of the well-known Willans high-speed type, in which the cut-off is effected by an excentric upon the crank pin. The boilers were supplied by an Austrian firm to Messrs. Crompton's specification, and are capable of developing 800 horse-power, reckoning 30lb. of water per indicated horse-power. Water is obtained from a well sunk on the premises, and is passed through Clark's combined feed-water heaters and filters, being finally forced into the boilers by a pair of Worthington high-pressure pumps. Provision is made for the ultimate increase of the whole of the plant to double its present capacity, inasmuch as the station is intended for the supply of other installations besides the one already at work. The mains are laid underground, and consist of lead-covered cables of the Berthoud-Borel type. We have previously given some account of the interior fittings at the Opera House, which are of a very substantial and elaborate description.

ELECTRO-MOTOR TARIFFS IN AMERICA.—There is at present great discrepancy in various cities in the States, both as to the method and the rate at which electric energy is supplied. The following tariffs, collected by the New York *Electrical World*, will, however, prove interesting. At Pittsburgh:

Where Company Owns Motor. Size.	Per month.	Where Subscriber Owns Motor. Size.	Per month.
½ horse-power	$10.00	½ horse-power	$6.00
1 ,,	15.00	1 ,,	10.00
1½ ,,	22.50	1½ ,,	15.00
2 ,,	28.00	2 ,,	20.00
3 ,,	40.00	3 ,,	25.00
5 ,,	60.00	5 ,,	40.00
8 ,,	72.00	8 ,,	55.00
10 ,,	80.00	10 ,,	60.00

The company runs its main line to the premises where the motor is to be placed, but all other connections and appliances for the purpose of utilising the power from that point are made at the cost of the subscriber.

At Buffalo, N.Y.:

Size.	Power per month.	Rental of Motor per month.
⅛ horse-power	$3.00	$0.50
¼ ,,	5.00	1.00
1 ,,	8.00	1.00
2 ,,	15.00	2.50
4 ,,	26.00	5.00
6 ,,	38.50	7.50
8 ,,	51.00	10.00
10 ,,	63·50	12.50
12 ,,	76.00	15.00

The above quotations are based on a service daily, except Sunday, from 7 a.m. to 6 p.m. Special prices are made where power is required for a different period. A discount of $1 per motor is made on bills paid on or before the 10th of month following service. Where motor is furnished by the company, a contract for at least one year's motor use is required.

At Laramie, Wyo.:

Horse-power delivered to customers.	Rates per horse-power per hour.	Rate for one hour.	Rate per month of 26 days in cases where consumer owns the motor.
40	2½ cents	$1.00	$260.00
20	2½ ,,	0.50	130.00
15	2½ ,,	0.37½	97.50
10	3 ,,	0.30	78.00
7½	3½ ,,	0.26¼	68.25
5	4 ,,	0.20	52.00
3	4½ ,,	0.13½	35.10
2	5 ,,	0.10	26.00
1	—	0.06	15.00
½	—	0.03	7.50
For sewing machines.	—	—	2.00

The Laramie station is about to supply 40 horse-power at $260 per month, as above, to a large flour mill about 150 feet away. The following are other rates quoted:—Detroit, $100 per horse-power per annum; Boston, 50c. per horse-power per day; Des Moines and four small towns, $100 per horse-power per annum at ten hours daily, constant load. New York averages $100 to $125 per horse-power per annum; Lawrence, Lowell, Harrisburg and Providence, $125 per horse-power per annum; Cleveland, Cincinnati and Baltimore, $10 per horse-power per month; Rochester (power derived from turbines at generating station), $50 to $72 per horse-power per annum. At Cleveland,

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twenty-four sewing machines rated at $\frac{1}{8}$ horse-power are run at $1 each per month. In all cases lower rates are charged for larger powers.

"THE ELECTRICITY OF CONTACT OF GASES WITH LIQUIDS."—Under this title there is an important letter from Mr. Enright in last week's *Nature*. "Since the delivery of Helmholtz's famous Faraday lecture 'the charge on the atom' has been assumed by physicists, notwithstanding the very serious objections urged by Maxwell against such a theory. A reperusal of the letter, some eighteen months ago, excited me to make some experiments on the subject." Experiments led at first to results of a very baffling and apparently contradictory character. A quadrant electrometer was connected on one side to earth and upon the other to an insulated stand on which was placed a porcelain dish, containing a small quantity of distilled water. Small pieces of potassium or sodium were thrown on the water, and the nature and amount of the charge left on the vessel was noted. This charge was of course opposite and equal to that obtained by the escaping hydrogen. With water the observations were inconstant and conflicting, but ultimately two definite and constant results were obtained: "(1) Na thrown on strong and pure acetic acid invariably left a positive charge on the insulated dial, the escaping hydrogen being negative; (2) a fragment of zinc thrown into strong HCl invariably left a negative charge on the insulated dial, the escaping hydrogen being negative." The next experiment tends largely to clear up the whole question. We omit the precautions observed and give the result:—"The porcelain dish was nearly filled with a 10 per cent. solution in distilled water of strong HCl. Three small fragments of granulated zinc were now dropped into the dilute HCl in the insulated dish. A very slight effervescence at once appeared. This gradually increased, but never became violent. In four minutes from dropping the zinc the spot could be perceived moving, and in four and a-half minutes more it moved twenty-eight divisions to the left, indicating the charge on the dish negative and the escaping hydrogen positive. The insulated stand, &c., was now disconnected from the quadrants. The spot maintained its position on the scale. In one and a-half minute after the quadrants were again connected to the insulated stand. The spot moved instantly twenty divisions more to the left. In one and a-half minute more it had moved ten divisions further to the left, but with a slower pace, and it presently stopped and turned back, at first slowly, taking five minutes to go back the sixty-eight divisions to the zero. In four minutes more it had moved eighty divisions to the right. The insulated stand was once more disconnected from the quadrants, and at the end of two minutes they were reconnected, when the spot instantly bounded up 55 divisions further to the right. It continued to move in the same direction until the effervescence ceased owing to the acid being exhausted. A quantity of the zinc survived. On short-circuiting the quadrants the spot returned to within four divisions of the original zero. As the reaction between zinc and hydrochloric acid proceeds, the quantity of chloride of zinc in solution continually increases, and so it appears demonstrated that when hydrogen passes through hydrochloric acid it acquires a positive charge, when it passes through chloride of zinc it acquires a negative charge. I believe that this inference may be safely very much generalised, but for the present I forbear. In confirmation of it, however, it may be well to mention that at any stage of the last experiment a deflection may be obtained to right or left as required by adding an excess of saturated chloride of zinc (for the first), or of hydrochloric acid (for the second). When it is known that the sign of the charge on escaping hydrogen depends upon the substance it has been in contact with, the very irregular results with K and Na already mentioned become less mysterious."

TRANSMISSION OF ENERGY.—COMPRESSED AIR v. ELECTRICITY.—*The Times* of August 24th contained an elaborate eulogy of the system of transmitting energy by means of compressed air, and, indeed, if commercial considerations be neglected, we should be disposed to agree with most, if not all, the writer says. That still more sapient oracle, the *Pall Mall Gazette*, evidently supposes that compressed air is a brand new invention, and, after reading the account, thus learnedly comments thereon:—"It is a good instance of the busy march of science in these days that while electricity is only on the threshold of its applications, a rival power should already be in the field, the substitution of air for steam! It would require volumes to expound all that would be meant by such a change," &c. Without employing "volumes" of vapour upon the subject, we would invite the attention of the *Pall Mall Gazette*, as representing the average non-technical mind, to the following facts and figures, premising only that *cost* is usually an essential consideration in matters of this kind. It has recently been shown by a writer in the French journal, *La Genié Civil*, that the efficiency of transmission by compressed air cannot exceed 45 per cent. for distances of about a quarter of a mile, while beyond this it is still less, and that the system is necessarily dearer than transmission by water pressure, except for distances exceeding about three miles. The calculation is based upon a total transmission of 100 horse-power. Now (quoting from the same writer) let us compare each of these methods with the cost of transmission by electricity and with wire ropes. The result is shown in the following table, where the original source of power is (1) steam, (2) turbines:—

System employed.	330 Feet.	1,640 Feet.	3,280 Feet.	16,400 Feet.	32,810 Feet.	65,620 Feet.	Motor.
	d.	*d.*	*d.*	*d*	*d.*	*d.*	
Electricity ...	1·80	1·84	1·94	2·27	2·84	4·61	Steam.
Water pressure	2·27	2·36	2·61	4·03	5·79	9·57	
Compressed air	3·17	3·23	3·33	4·05	5·25	6·39	
Ropes	1·26	1·49	1·58	2·88	4·99	12·68	
Electricity ...	0·40	0·48	0·53	0·62	0·68	1·15	Hydraulic.
Water pressure	0·47	0·55	0·62	1·33	2·23	3·54	
Compressed air	0·77	0·80	0·84	1·21	1·86	3·36	
Ropes	0·26	0·27	0·30	0·80	1·42	3·39	

It will be seen that for 100 horse-power compressed air is absolutely the most expensive method in all cases. For distances less than 16,400ft. wire ropes are at first cheaper, while beyond such distance electricity comes rapidly and unmistakably to the front. But immediately we contemplate not merely the transmission but also the *distribution* of energy, ropes are altogether out of the question, and cannot for a moment compete with electricity for convenience and ease of handling. Relative calculations of this general nature do not, of course, pretend to anything more than an approximate degree of accuracy; but it may be stated that similar calculations by independent authorities have invariably given results of the same general character. (See, for instance, the valuable tables in Kapp's "Electrical Transmission of Energy.") The proof of the pudding is, after all, in the eating, and it may astonish *The Times* and the *Pall Mall* to learn that in America there are already in active operation about 10,000 electro-motors, of which the great majority receive current from central stations for the distribution of light and power. Such stations number about 250, scattered in almost as many different towns.

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COMPARISON BETWEEN THE VIEWS OF DR. ARRHENIUS AND PROF. ARMSTRONG ON ELECTROLYSIS.

REPLY TO PROF. LODGE'S CRITICISMS.

BY HENRY E. ARMSTRONG, F.R.S.

A Communication to be made to the Electrolysis Committee of the British Association.

Prof. Lodge in his summary very clearly points out the difference in the views advocated by Arrhenius and myself, and emphasises the chief points which it is of importance to discuss. He unreservedly condemns my hypothesis, on the ground that any E.M.F., however small, is sufficient to produce sensible electrolysis; and he asserts this to be a proof of the correctness of the orthodox view that the E.M.F. has nothing to do but to give direction to the already separated atoms. I have before expressed my doubt of the force of this argument; but I may add that it appears to me hopeless to attempt the experimental disproof of such a statement, our ability to prepare pure substances being out of all proportion small as compared with our power of detecting electric currents: indeed, it would be presumption to attempt to contend with an engine of such surpassing delicacy as "a galvanometer sensitive enough to show a current which could only decompose a milligram of water in a century."

It is apparently desirable that I should more fully state, from a chemist's point of view, the chief reasons which cause me to hesitate in accepting the "atomic dissociation hypothesis," and which have led me to suggest an alternative "molecular hypothesis," viz., that in the case of "composite electrolytes," at all events, electrolysis is the outcome of the combined action of the E.M.F. and of some effect which the one set of molecules exerts upon the other set while both are under the influence of the E.M.F. I care little at present what the effect is, the important question to settle being whether electrolysis is primarily an affair of atoms or of molecules.

1. In explanation of the fact that neither hydrogen chloride (HCl) nor water (H_2O) is an electrolyte, although a solution of the one in the other conducts readily, it has been sometimes assumed that the dissociated atoms of H and Cl are shielded and prevented from recombining by the intervention of the neutral molecules of the solvent, opportunity being thus given for the E.M.F. to act and give direction to the atoms. But a *single* substance such as fused silver iodide, for example, conducts readily, and is electrolysed. How are we to explain this? I imagine that the orthodox view also in this case requires us to assume that there are, normally present in the iodide, dissociated iodide and silver atoms; just as it is assumed that there are atoms of H and Cl in hydrogen chloride, or of H and O in water. Why, then, does electrolysis take place in the one case, but not in the other? The conductivity of such a substance as silver iodide is far too considerable to be explained by the assumption that it contains impurity, which, judging from the behaviour of aqueous solutions, could not possibly be present in sufficient amount to account for the readiness with which the electrolysis takes place. Nor can we, with any degree of probability, suppose that either hydrogen chloride or water in the pure state consists wholly of Arrhenius's complex inactive molecules; that silver iodide is at all events rich in simple active molecules; and that such simple active molecules are produced from hydrogen chloride only on its dilution with water. Nor do I conceive that it helps us to assume that a compound of hydrogen chloride with water is formed; it does not appear to me to be probable that an aggregate of the form $(HCl)_y \cdot (OH_2)_x$ would be more susceptible of electrolysis than the component simple molecules, and that these would be more likely to suffer dissociation when associated than when free. Unwieldy aggregates, such as Prof. Lodge refers to, break up, I imagine, if at all, not because some of the outlying atoms are not held with full vigour, nor because the atoms of the one constituent molecule are by collision of the aggregates brought close to those of the other, but because the atoms of the molecules which form the aggregate are brought into *intra-molecular* relationship; *i.e.*, the break up is not the result of the collision, but of the opportunity thus given for re-pairing to take place,* and possibly new simple molecules, *not atoms*, always result.

2. Again, it appears to me that the atomic dissociation hypothesis requires that the majority of compounds, if not all, should *per se* conduct more or less well, especially if it be admitted that ionic velocities differ; as a matter of fact, however only a very limited number can be regarded as electrolytes. Moreover, according to the orthodox view—particularly in the form in which it is stated by Arrhenius—the most active substances are those which contain the greatest number of active atoms, *i.e.*, those which are most easily dissociated. But, in point of fact, the substances which are most active—both chemically and electrically—are by no means those which we should regard as most likely to dissociate; thus, HCl, HBr and HI differ in stability to a very marked extent, yet their molecular conductivities in aqueous solution are almost identical. And a glance through the list of salts which are believed to be *per se* electrolytes is sufficient to show that these are not as might fairly be expected among the least stable, but quite the contrary: silver chloride, bromide and iodide, for example—all compounds of considerable stability—being the best conductors known, I believe, among simple electrolytes.

3. Aqueous alcoholic solutions generally oppose a greater resistance than the corresponding aqueous solutions, and solutions in absolute alcohol oppose a practically infinite resistance; yet surely it might be expected that alcohol—indeed, any neutral solvent—would screen the dissociated atoms from each other and thus render electrolysis possible.

4. If, as Prof. Lodge asserts, the orthodox view (or his version of it) pictures the dissociation of water by salt quite as easily as that of salt by water, why is conduction assumed by Kohlrausch and others to take place only through the agency of the atoms of the dissociated salt, and not at all through that of the water, except, perhaps, to judge from a recent admission made by Kohlrausch, in the case of *very dilute* solutions? Certainly, on the atomic dissociation hypothesis, both water and salt, I imagine, are to be regarded as dissociated; and moreover, it would appear probable that as the dissociated constituent atoms of water would have less chance in a concentrated solution of coming together again, conduction would take place mainly through their agency; and that in a dilute solution, for a similar reason, conduction would be affected chiefly through the agency of the salt. This conclusion is manifestly opposite to that arrived at by Kohlrausch.

5. Arrhenius asserts that the conductivity of ammonia solutions is caused by a small quantity of NH_4OH, which is increased by dilution; and in reply to Prof. Lodge's remark deprecating this statement (B.A. *Report*, 1886, p. 363), he says: "I may say in explanation that almost all chemists attribute the reaction of ammonia to a small portion of NH_4OH in it, &c." I am one of those chemists who think that it is not necessary to make this assumption, believing that the chemical changes produced by ammonia solution are due to the combined or simultaneous action of ammonia and water, but I quite agree with Arrhenius that the effect of dilution is to increase the proportion of simple or active molecules, *i.e.*, to dissociate the molecular complexes into the constituent simple molecules of ammonia. The opinion is common among chemists that the nitrogen becomes separated from the hydrogen not by direct electrolysis, but by means of oxygen primarily produced by electrolysis—in other words, that water is the electrolyte.

6. The dissociation hypothesis has not only found favour with physicists, but also with chemists, as it long seemed to afford a simple explanation of the occurrence of chemical change; in fact, the popular view may be summed up in the simple statement that simplification as a rule precedes complication. As I have more than once insisted, however, recent observations on the influence of minute amounts of third substances oblige us to admit that we have yet much to learn regarding the manner in which apparently the simplest changes

* This view is in entire agreement with one I expressed in the communication referred to; indeed, it may be considered a paraphrase of it.—O. L.

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occur. In certain cases where we may almost assert that we know dissociated atoms to be present, combination or interchange does not ensue unless a minute amount of a third apparently neutral substance be present; indeed, the great problem in chemistry, which is but now being attacked, is whether it is possible for chemical change to occur between *any two* substances, be they simple atoms or more or less complex molecules. Even dissociation would seem not to be a simple function of temperature, as is well shown by the observations of Deville and Victor Meyer and Langer that the decomposition of carbon dioxide takes place in porcelain at a temperature several hundred degrees below that at which it occurs in platinum vessels. Moreover, there are not wanting chemists who assert that complication, not simplification, is the usual antecedent of chemical interchange.* No less an authority than Kekulé advocates this view, and I have recently had occasion to discuss its application in explanation of the laws of substitution in the case of carbon compounds. I do not mean for one moment to assert that anything which we know of the conditions on which chemical change depends negatives beyond question the dissociation hypothesis, but merely that it is possible, apparently, to explain the facts by means of a molecular hypothesis.

7. It appears to me that an almost conclusive argument in my favour may be based on the results of Lenz's determinations of electric conductivity and diffusivity embodied in the following table, where v is the volume percentage of alcohol, d the diffusivity, and L the conductivity; the values for an aqueous solution containing half a gram-formula-weight of potassium iodide being put = 100:—

	KI.		½ KI.		¼ KI.		⅛ KI.		1/16 KI.	
v	d	L	d	L	d	L	d	L	d	L
0	195	—	100	100	51	52	27	27	13	14
27·9	—	—	50	50	25	25	—	—	—	—
51·0	—	—	33	35	19	18	11	9	—	—
74·7	—	—	29	26	15	13	8	8	—	—

	½ NaI.		½ K_2CrO_4.		½ CdI_2.		¼ CdI_2.	
v	d	L	d	L	d	L	d	L
0	82	80	—	104	84	30	44	18
27·9	38	40	64	63	40	14	19	7·5
51·0	—	—	—	—	37	9	17	4·5
74·7	27	23	—	—	39	6	17	3·5

It will be observed that the numbers run strictly parallel, except in the case of the cadmium salt; and here the exception proves the rule, as it is established, beyond doubt, by a variety of consistent observations that the cadmium salts are of exceptionally complicated molecular composition. I entirely fail to see how we are to explain liquid diffusion by means of the atomic dissociation hypothesis. But if we assume that the water molecules are in motion, and that having an attraction for the molecules of the dissolved body they necessarily tend to drag them forward, the phenomena are of the same order as those of conduction on my hypothesis. The diminution in conductivity and also in diffusivity as the amount of alcohol is increased is most striking. If the solvent be neutral the substitution of alcohol for water should have little influence; but if, as I suppose, the solvent be active, alcohol being far less active than water, the effect to be expected is precisely of the nature of that observed.

8. With regard to Prof. Lodge's remark, "It is not easy to imagine why his molecules should be travelling past each other in the fluid," it is admitted by the orthodox that the E.M.F. gives direction to the atoms. Why, then, should it not also give direction to the moving molecules if these are still possessed of "residual affinity"—*i.e.*, if some portion of the original charge of the atom be still unneutralised? He then adds, "nor why, even if they did, this fact should assist their previously incompetent forces to disrupt each other." Let me put a case. Imagine a couple of individuals holding each other by the hand to waltz rapidly round a room, and suppose a second couple to do the same: if, as the couples passed each other, one of the individuals were to grab at one of the members of the other set, might not the members of the one or the other couple part company?

9. Ostwald's remarkable contributions to our knowledge of molecular conductivity appear to me to bear continuous testimony to the existence of such an influence of molecule upon molecule as that I have pictured. I have given numerous illustrations from his work in my Royal Society paper, but I may here call attention to his numbers for hydrocinnamic, cinnamic, and phenylpropiolic acids:—

	v=32.	64.	128.	256.	512.	1024.	2048.	4096.
Hydrocinnamic Acid ..... $C_6H_5.CH_2.CH_2.CO_2H$	2·25	3·14	4·40	6·08	8·42	11·55	15·71	20·92
Cinnamic Acid. $C_6H_5.CH.CH.CO_2H$	—	—	—	7·55	10·37	14·18	19·18	25·28
Phenylpropiolic Acid ..... $C_6H_5.C.C.CO_2H$	27·66	35·29	43·67	51·98	59·13	64·56	67·96	69·56

The numbers show that the "activity" of the acid increases as hydrogen is withdrawn. On the orthodox view the ions are *H* and *the acid minus H*; but it is difficult to conceive that the affinity of the negative ion for H should diminish as that ion becomes deprived of hydrogen, and that that acid should be the strongest—*i.e.*, conduct best—because most dissociated, which it is to be imagined would be the least ready to part with hydrogen.

10. Arrhenius certainly bases his conclusion on the orthodox view of atomic dissociation, but in his calculations makes use of the conductivity values determined by himself or Kohlrausch; it seems to me, therefore, that his results are in the main independent of any theory of the nature of electrolysis. To use his words, "L'activité electrolytique se confonde avec l'activité chimique;" or, to put it in another way, which much of our chemical experience appears to warrant, the formula by which Ohm's law is expressed

$$C = \frac{E}{R}$$

may also be used as representing the law of chemical change, C being the amount of change and E the intensity of the total chemical effect. An argument based upon electrolytic values may therefore be expected to be in agreement with chemical experience.

In conclusion, I would add that I urge these pleas on behalf of my hypothesis with the greatest diffidence, feeling that I am unfortunately unable to fully appreciate the force of the mathematical and physical arguments. I do think, however, that in framing our conceptions we may, perhaps, have been too much guided by statistical principles; it is quite open to question whether the *atoms* in molecules are in that state of unrest—are perpetually changing places in the manner in which our fancy has allowed us to picture them to be. We have yet almost everything to learn regarding inter-atomic structure, and everything regarding intra-atomic structure. It is impossible at present to quantify peculiarities and relationships which are patent to the chemist, but these must be taken into account; and for this reason it is all important that chemists and physicists should co-operate. These discussions must be of great value in bringing us together, and in enabling us to understand each other. Our thanks are due especially to Prof. Lodge for having so happily devised a means of promoting discussion.

20th August, 1887.

* This is in harmony with the "third view" of electrolysis set forth in my paper.—O. L.

INCANDESCENT LAMP MANUFACTURE.—XXIII.

BY J. SWINBURNE.

Testing (concluded).

Testing the life of lamps is a very difficult matter. No accurate or useful tests of the life of lamps has yet been made, though considerable trouble and expense have been devoted to this object.

The failures in these cases have been due to misunderstandings as to the proper methods of testing lamps, so that though great care has been bestowed on the work the results are, unfortunately, of little value.

In testing lamps for long periods two things are to be considered, the breakage of the carbon and the diminution of light either through the resistance of the carbon rising or through the bulbs being blackened.

To find which of several types of lamps has the longest life at a given efficiency it is necessary to have a source of perfectly constant electromotive force at hand. It is evident, for

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instance, that running a lamp for a month at ·3 candle per watt is not the same as running it for two weeks at ·25 candle per watt and two at ·35 candle per watt. Until we have tests of lamps run till they break at one constant efficiency we cannot tell the best efficiency to run lamps. Even if we had the results of such experiments they would be of little value, because in ordinary installations the electromotive force is not constant; so that a lamp which would run for 1,000 hours on a circuit in which it gave a mean efficiency of 3 candle per watt, varying from ·25 to ·35 candle per watt, would not last so long on a circuit which gave a mean efficiency of ·3 candle per watt, varying from ·2 to ·4 candle per watt. To talk of the life of lamps as is usually done is absurd.

The commercial value of lamps of different types can be approximately obtained by imitating the conditions. There is little doubt that there is a certain temperature below which a carbon will last practically for ever, and above which it will soon break. This temperature varies with different kinds of carbon, and no doubt also depends on the difference of potential between the terminals, and on the thickness or mechanical strength of the carbon. There is a sort of silent discharge, which increases very rapidly at one temperature or one electromotive force in a lamp. This can be shown by putting a third terminal with a galvanometer and performing the experiment devised by Mr. Edison. Though the best efficiency to run lamps cannot be determined, as it depends on the installation, it is possible to find which of several types of lamps is the best. Several lamps are taken, and carefully measured at the same efficiency. They are then arranged in parallel on any convenient circuit. If the lamps are not of the same electromotive force resistances are inserted, so that all need the same electromotive force on the terminals of the lamps and resistances to give the same efficiency. The whole of the lamps are then slightly overrun to an extent varying according to the government of the engine. Those that break last are evidently the best lamps.

Exhaustive tests of this sort carried out on lamps of different makers and of different types would be of great value. The writer has carried out a considerable number, but his were not to determine which maker made the best lamps, but to see which type was the best. In all cases he found that amyloid carbons were good, though silk seemed better, this advantage being, however, compensated by the difficulty of working silk. In most cases—in fact, in practically all—a low-resistance electromotive force lamp was better than a high.

In such tests the lamps must of course be run at the same efficiencies. The American tests were made with the lamps at different efficiencies. This method only tests lamps for breaking. If a lamp's resistance increases, its efficiency falls so that it protects itself to some extent. The lamps should therefore be tested every now and then to see that there is no alteration of resistance. A lamp that runs up in resistance may be considered as broken, because it is worse than useless, for on an installation it gives very little light in proportion to the power it consumes, and people do not think of replacing it. This source of error can be avoided by putting some of the competing lamps in series and some in parallel. Thus, if two types are being tried against each other, one set is arranged with the types in parallel, so that if one rises it protects itself, and if one falls it is overrun and broken; and one set is arranged with the types in series, so that one that rises in resistance is more overrun than one that remains constant or one that falls. A new carbon that has been insufficiently flashed falls in resistance first, and rises again later on, so that by testing at any part of its career a lamp can be sent out to rise or fall with age.

Profs. Ayrton and Perry and Fleming read very interesting papers at the Physical Society in 1885, in which they consider the question of the most economical efficiencies for incandescent lamps. The chief difficulty in such questions is to get accurate data, and the errors arising from the inaccurate and unreliable data are so great as to make the conclusions of no practical value. Before problems dealing with incandescent lamps can be treated mathematically the term candle-power must be defined, as already explained. The writer would, with diffidence, propose his definition as simple and practical.

The question of the life of lamps with alternating currents has never been properly investigated. There is reason to suppose, however, that alternating currents are not so good as direct. In the first place, the extreme difference of potential between the terminals of the lamp is very much greater with alternating currents, so that there is very much more tendency to visible or invisible discharge with a lamp of given resistance. A lamp with a thin carbon run on an alternating circuit with a given electromotive force or electro-dynamometer reading, gives more light and is more overrun than a thick one. This is because the thin carbon does not remain at a uniform temperature corresponding to the average power spent, but follows the rise and fall of electromotive force to some extent. The carbon is hottest just after the highest electromotive force has been reached. Thus, if a thick carbon which cannot follow the changes of electromotive force runs at an efficiency of ·3 candle per watt, a thin one will apparently run at a higher efficiency. If the candle-power were proportional to the power, the average efficiency of the thin carbon would also be ·3 candle per watt, but as the light increases more rapidly than the power, it runs at a higher efficiency, and gives more light. The life of the lamp does not depend, however, on the average efficiency, but on the highest temperatures the carbon reaches, so that on an alternating current a lamp should only be run so that its highest efficiency corresponds to the normal efficiency on a direct current circuit, so that its average efficiency must be lower. It seems at first sight paradoxical that the thin carbon should, with a given power, give a higher efficiency on an alternating current than on a direct, and should therefore need to be run duller, not till it is at the same efficiency, but till it is at a lower efficiency in order to last as long, but a little consideration of the points here brought forward will show that it is so.

At one time the writer thought that the resistance of carbon varied with the current density as well as with the temperature; but further experiment seems to show that this is not the case. The resistance of carbon falls with the rise of temperature till the carbon reaches the temperature corresponding to about ·3 candle per watt when the resistance is stationary, above this temperature it rises again. The resistance is sufficiently constant to be taken so in considering alternating currents. The decrease of resistance of carbon with rise of temperature is sometimes supposed to be quite anomalous, but many other bodies, such as organic compounds, do the same.

The next difficulty with alternating currents is their measurement. Apart from the fact just noticed, lamps are apt to be overrun because voltmeters have self-induction, and therefore read too low. If a dynamometer, calibrated by a direct current, were used to measure the electromotive force, it would be accurate for incandescent lamp work if it had no self-induction, but its self-induction would make it read too low. To avoid this error, the voltmeter must be made of low resistance, and a resistance made without self induction must be put in series with it. Such instruments as a Siemens dynamometer wound as a small current ammeter, with a resistance in series to make it a voltmeter, and a Siemens ammeter, if its wire is not too thick, may be used in alternating current incandescent lamp work, and the currents may be treated as if they were direct—that is to say, the power may be obtained by multiplying the electromotive force as read on the voltmeter by the current as read on the ammeter. The Cardew voltmeter may be used also, and as its self-induction is probably inappreciable, it is, perhaps, the best instrument for the purpose. If it has any error due to its heating and cooling rapidly, it is of the same kind as that of the lamps, so that such an error is beneficial. It is needless to remark that these instruments may only be used on the lamp circuit itself; a dynamometer voltmeter or ammeter, or a Cardew instrument must not be used on the primary circuit of an induction coil, for instance, or anywhere where there is self-induction in the circuit. The dynamometer or electrometer connected as a watt-meter is the only instrument available, and even this demands certain precautions.

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Conclusion.

One or two points only remain to be mentioned before taking leave of this subject.

The methods of making fancy or coloured lamps have already been described by Mr. Cherrill, who has had considerable experience in the matter, and in incandescent lamp work generally (*The Electrician*, April 8, 1887). The writer has also used negative varnish, with aniline colours dissolved in it. One or two dyes will not dissolve in varnish, but as the dyes are so very numerous this is a matter of little importance. The writer has used a solution of gelatine in acetic acid as a solvent, and this in many cases gives very good results.

Messrs. Zanni and Shippey have taken out a patent referring to lamps with ornamental globes. One form is made with one side clear and the other opal, so that when the lamp is used for such purposes as lighting billiard tables, the opaque side acts to some extent as a reflector. They also make lamps of corrugated glass so that the light is more diffused.

Messrs. Woodhouse and Rawson deposit silver on one side of the lamp, so the whole of the light is thrown in one direction.

Lamps are apt to be broken in transit if not carefully and properly packed. If the lamps are in large quantities they should be packed in casks, as porters are apt to drop boxes and break lamps, but they roll casks. Smaller quantities should be done up in small light boxes that can easily be lifted with one hand.

THE ELECTRICAL CONDUCTIVITY OF SOLID SALTS UNDER GREAT PRESSURE.—A paper by L. Graetz on the above subject has recently appeared in the *Repertorium der Physik*, of which the following account is given in the *Abstracts* of Foreign Periodicals issued by the Institute of Civil Engineers:—It is well known that the metallic salts in a solid state offer at low temperatures a high resistance to the electric current, but begin to conduct at temperatures even far removed from their fusing point, and that the conductivity increases with further rise of temperature. As regards the electrical resistance of such salts when in solution, this may in some measure be identified with the resistance presented to the mechanical movement of the electrified molecules; and it should therefore follow that the salts in a molten condition would act as conductors of electricity; but the fact that they begin to conduct before this change of condition takes place points to some other connection between electrical conductivity and molecular motion, a conclusion arrived at by Kohlrausch from his experiments on iodide of silver, where no sudden change in its resistance was found at the passage from the solid to the molten state. If, however, electrical conductivity of such salts be assumed to follow on the same lines as thermal conductivity—that is, to be a function of the frequency of molecular collision—then subjection of the solid salt to pressure should alter its conductivity in the same direction as has been observed to follow increase of temperature. The author's experiments, which have evidently been made with the utmost care, most conclusively confirm his arguments thus set forth. The screw press, by means of which an estimated pressure per square inch of about 700 atmospheres could be obtained, consisted essentially of a plunger working in a cylindrical hole, the sides of each being well lacquered, and a sheet of mica inserted to insure insulation between the two, so that the end of the plunger and bottom of the cylinder alone formed the electrodes, the distance between them being given by an index suitably affixed. The substances under examination required most careful desiccation, the completeness of which process was beautifully indicated by the behaviour under the electrical test; thus, if the salt were not free from uncombined water, the resistance was found gradually to increase after the application of the pressure, owing to this water being slowly expelled to the surface, and on suddenly releasing the pressure a great decrease in resistance followed as a result of the water re-entering the capillary cavities; on the other hand, with the salt perfectly dried, the opposite result was noticed, owing to the less intimate contact between the electrode and the salt.

BRITISH ASSOCIATION PAPERS.

ELECTRICAL PAPERS TO BE PRESENTED TO SECTION A.

The following is as complete a list as it is at present possible to give of the electrical papers to be read in Section A at the forthcoming meeting of the British Association in Manchester:—

A.—ELECTRICITY.

Mr. GLAZEBROOK, F.R.S., will present the report of the Committee on Electrical Standards, to which there will be one or two interesting appendices, including an unpublished chart by Prof. FLEMING. This report may give rise to discussion.

Dr. LODGE, F.R.S., will present the report of the Committee on Electrolysis. This will be considered at a joint sitting of sections A and B, very probably on Saturday, 3rd September, as an animated discussion is expected. Several papers in connection therewith will be read, including one on the Electro-deposition of Alloys, by Prof. S. P. Thompson.

Messrs. HALDANE GEE, HOLDEN, and LEES, of the Owens College, will have a paper on Electrolysis and Electrolytic Polarisation.

Mr. GEE will read a paper also on a Comparison-Magnetometer, which he will exhibit, and will join Prof. STROUD in a paper on a null method in Electro-calorimetry.

Sir WM. THOMSON will exhibit his deci-and-centi-ampere balances, and read a paper on their application to measure the E.M.F. of a single cell.

Mr. PREECE, F.R.S., will read papers on the Coefficient of Self-induction in Telegraph Wires and on Electrical Induction between Wires and Wires, the latter being in continuation of a communication made last year to the section.

Prof. EWING, F.R.S., and Mr. LOW have papers—1. On the Magnetisation of Iron in Strong Fields; 2. On the Magnetisation of Hadfield's Manganese Steel in Strong Fields; 3. On the Influence of a Plane of Transverse Section on the Magnetic Permeability of Iron.

Profs. THORPE, F.R.S., and RÜCKER, F.R.S., will give further details of their new magnetic survey.

Mr. A. P. TROTTER will read a paper on the production of a constant current with varying E.M.F. from a dynamo, and will exhibit a dynamo constructed on the principle he wishes to utilise.

Prof. LAMB, F.R.S., will read a paper on the theory of electrical endosmose.

Dr. E. HOPKINSON has a paper on the general theory of dynamos.

Mr. W. LANT CARPENTER offers a paper on certain suggested improvements in cable signalling, with a view of greatly increasing the speed of signalling.

Prof. S. P. THOMPSON has papers on (1) The Temperature Coefficient of E.M.F. in Accumulators; (2) the Prediction of the Tractive Force of Electromagnets.

Mr. KILLINGWORTH HEDGES suggests an improvement in the construction of secondary batteries.

Mr. J. SWINBURNE offers a paper describing Some Experiments on Standardising by Mercury-Voltameters.

Mr. GLAZEBROOK, F.R.S., will exhibit an induction-coil made by Mr. Higgs.

Prof. SCHUSTER, F.R.S., will communicate a paper on magnetism, by Prof. SCHERING.

Prof. PRITCHARD, F.R.S., has a paper on Sir Howard Grubb's Electrical Control of Telescope Driving Clocks.

Prof. BALFOUR STEWART, F.R.S., will communicate the Report of the Committee on Magnetic Observations.

Hon. R. ABERCROMBY has a paper on the different varities of thunderstorm, and will suggest a scheme for their systematic observation in Great Britain.

Besides the above a number of electrical papers will be read in Section G.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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THE BRITISH ASSOCIATION.

After an absence of more than a quarter of a century the BRITISH ASSOCIATION will next week revisit the industrial capital of the British Empire. This is the third occasion on which this annual gathering has assembled at Manchester, the first being in 1842, and each time the event has been a notable one in the annals of the ASSOCIATION. Partly because of the central position of the place, but chiefly, no doubt, because of many local celebrities whom Manchester has produced, these visits of the BRITISH ASSOCIATION have invariably aroused an interest and even an enthusiasm which differ not only in degree but in character from the respectful and formal hospitality that this representative body of scientists is in the habit of receiving elsewhere. To mention JOULE, and DALTON, and FAIRBAIRN, whose names are intimately associated with the great cotton metropolis, is enough to account for this distinguishing characteristic of its inhabitants. This year a man hardly less eminent in his special walk of science than any of those just named will occupy the presidential chair, and Manchester claims him as her son. The meeting was there in 1842, when, in the place of DALTON, whose health was too feeble to accept the position to which he was entitled, Lord FRANCIS EGERTON presided. The second meeting was presided over by FAIRBAIRN, and is remembered as the largest which the ASSOCIATION has ever yet commanded. But next Thursday's meeting promises to outstrip all previous records both in respect to the scale of liberality on which the preparations are being made, and the number of visitors who will profit by them. The fact that Sir HENRY ROSCOE is to be presiding genius of the occasion seems to have spurred the Manchester folks to testify that not only can they produce great men, but that they know how to welcome others of the same stamp, come whence they may.

It happens, too, that the Manchester Jubilee Exhibition is still open, and it will be an attractive as well as useful feature to many of the intending guests. The scientific colleges, societies, and clubs, of which the city possesses a remarkable number, will all be at the disposal of members of the ASSOCIATION, and the amplest provision has been made for their entertainment and comfort. This is what we might expect of a place which can boast of Owens College and Victoria University; but all the same it is not invariably the case that citizens so highly favoured rise to the level of their privileges; and it is one of the most encouraging indications of the growing reputation of scientific pursuits among a people whose chief avocations are manufacture and trade, that the principal inhabitants of Manchester, supported by the whole population, are throwing themselves heartily into the work of giving a fitting reception to an association whose chief object is the advancement of science. But for this, probably the BRITISH ASSOCIATION would not have been able on the present occasion to have taken a step forward in making these gatherings more international than they have hitherto been. Upwards of 100 foreign men of science have accepted invitations to become guests during the forthcoming meeting. According to *The Times* the selection has been made by ascertaining of the various scientific societies in this country the names of those whom they regarded as the most representative men abroad in their own special departments. The result is that a brilliant array of foreign scientists will be present, especially in the branches of chemistry, physics, and biology, such as has never before graced the proceedings of this or any other learned society.

It is interesting to look back to the *Transactions* of the Society to see the part played by electrical matters in these previous meetings at Manchester. Of those who contributed to the business of the ASSOCIATION in 1842 almost the only one still with us is JOULE, who then read a paper on "The Electrical Origin of the Heat of Combustion." A paper of some interest at the present meeting, when the Chemical and Physical Sections will discuss the Report of the Committee on Electrolysis, was read in 1842 by Prof. SCHÖNBEIN on "The Electrolysing Power of a Simple Voltaic Circle." Various papers were also read at that first meeting on "Terrestrial Magnetism." Coming to the meeting in 1861 we find a large number of papers, showing that electricity was becoming of greater importance in scientific circles. Several papers related to earth currents and similar phenomena, and some others to the magnetic action of compasses. It was at this meeting that Mr. LATIMER CLARK and Sir CHARLES BRIGHT read their now historic paper on "The Formation of Standards of Electrical Quantity." The subject never after this was allowed to drop, and the result was the British Association "Committee," which has done such excellent service on this subject for our science. The late FLEEMING JENKIN read a paper at this meeting on "Permanent Thermo-electric Currents in Circuits of One Metal." Mr. J. P. GASSIOT, F.R.S., read a paper on "The

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Deposit of Metals from the Negative Terminal of an Induction Coil during Discharge and Vacuo." C. W. SIEMENS read one on "An Electrical Resistance Thermometer for Observing Temperature at Inaccessible Situations." It may also be worthy of notice that the president of this year, Sir H. E. ROSCOE (then Mr. H. E. Roscoe), together with R. ANGUS SMITH and Dr. E. SCKUNCK, reported on the recent progress and present condition of manufacturing chemistry in the South Lancashire district. Then, as now, the magnetic survey of Britain seemed to possess considerable interest for a certain section of the members, and papers on this subject were read at the meeting.

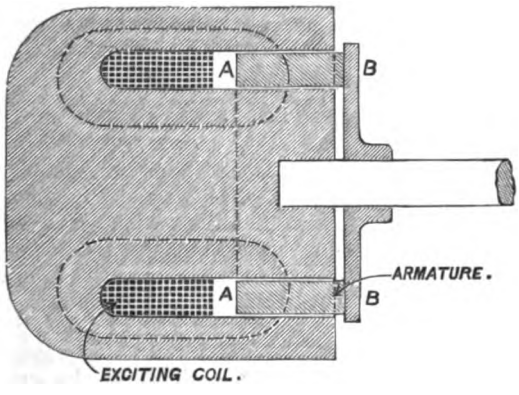
CORRESPONDENCE.

THE FORBES NON-POLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: About a year ago I was thinking of a means of generating a current of electricity on a plan identical with that of the Forbes machine. Prof. Forbes had already produced his dynamo, but I had not heard of it.

In this state of ignorance I wrote to you describing an apparatus with toad-stool shaped field-magnet, differing only from the arrangement now shown in the armature, which



Longitudinal section through axis.

I represented by a wire, which might be considered as a piece of the armature now shown projecting into the field space and parallel to the axis. I did not describe any sliding contacts, which would obviously require to be placed against each end of the armature at A and B, but asked you whether any E.M.F. would be produced in the wire when revolved. With your permission I will quote the following from the private reply which you kindly sent me:—"Your difficulty as to the generation of E.M.F. by a uniform field arises from confining your attention to 'a conductor' instead of to the circuit of which it forms part. If the circuit be wholly within the uniform field, then no E.M.F. is generated so long as it moves in any direction while remaining parallel to itself or to its own plane; in any other case the number of lines traversing the circuit changes its value and a current is generated. If the circuit be not wholly within the field, any motion of that part of the conductor within the field will obviously change the number of lines passing through the circuit, save in the particular case when the motion is parallel to the lines themselves." In consequence of this reply I lost confidence in my idea, and later on, when I got possession of Kapp's "Electrical Transmission of Energy," I was a little surprised to see a description of my castaway device, the non-polar dynamo.

Now, Sir, I am convinced that the statement that the "number of lines passing through the circuit must change in order to have a current" is not true of this dynamo; nevertheless Mr. Scattergood tenaciously upholds its correctness. From his last letter I quote, "There was a slip in my last letter, where I said that the number of lines passing through the circuit varied from zero to a maximum and back to zero. Of course the number increases (or decreases) continuously at each revolution." This altered statement of his view is even more incomprehensible than the first. There are only three ways of looking at it. At the end of each complete revolution and the commencement of the next the conditions are precisely similar. That is undeniable. And I want to know what becomes of the lines which have entered the circuit during each revolution. (1) Does their number continuously decrease at the same time and rate as it continuously increased? "Which is absurd," as Mr. Euclid would have said. If not, (2) do the lines which have entered during a revolution instantaneously quit the circuit as the next revolution begins? Zounds! What an E.M.F. that would produce—infinite is the word for it. But this is worse than the first alternative. (3) Does the number of lines in the circuit go on increasing while the machine is kept running? If so, then when the motion ceases the magnetism in a few moments disappears, there is a stampede of all the accumulated lines out of that circuit. Fortissimo! What happens to the dynamo? "Of course" I would counsel Mr. Scattergood to relinquish this theory.

Had not Mr. Thompson stated in his last letter that he had carefully read my last and previous letters, I certainly would not have thought it so. I think if he re-reads the 6th and 7th paragraphs of my last letter, he will perceive that he has missed the chief points, and attached far more significance to others than my language warrants.

I will briefly recapitulate the main points I have put forward during the discussion, as I do not appear to be properly understood:—(1) I assume there is a reaction equal and opposite to the pressure exerted by Forbes's armature when working which tends, through the medium of what is called "lines of force," to drive something round with it. (2) That that something (in which this reaction has its seat) is either the exciting coil (as Mr. Thompson has it) or the iron of the field magnet; or, as is most likely, that portion of the galvanic circuit which is distinct from the armature and connected with it by sliding contacts. (3) That it may in a slight degree be due to mere molecular friction in the iron of the magnet, &c., due to the movement of the lines therein. (4) I have demonstrated (paragraph 6 last letter) that it cannot possibly be due to Foucault currents. Here I would ask Mr. Thompson how it is, if he read the paragraph referred to, that he says: "Mr. Snowdon knows well that the Foucault currents are by far the most potent, if not the only cause, &c." (5) It has also been shown that if the armature drives the lines round with it, they must cut the stationary portion of the circuit in the opposite direction, and to the same extent that they would have cut through the armature, so that the E.M.F. is the same either way. (6) I hold that E.M.F. current or no current is invariably produced when lines traverse a conductor, whether the number of lines in the circuit changes or not.

I have always regarded as feasible the doctrine that the lines are *quasi* fixed to the exciting coil, but that the pressure of the lines of force is entirely confined to the conductors in which they are generating current is far more likely to be true.

I may say that when I first sought information on this point I was endeavouring to think of a means whereby to obtain high E.M.F. in a non-polar machine.

Various devices more or less simple suggested themselves. One was especially simple, and theoretically, at any rate, involved no diminution of efficiency; but in all cases the objectionable sliding contacts presented themselves, and it was in endeavouring to dispense with them that I wanted to find that the exciting coil really held the lines fast.

Mr. Sprague's views on the subject of magnetism seem to me the most advanced with which I have made acquaintance, but I do not get the information I want from his theory.

Of course, it is the stationary conductor in Forbes's machine which opposes resistance to the circulation of the lines; then, if suitably arranged apparatus were employed, it should be

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possible to observe a deflection of this part of the circuit under the stress.

I would be happy to confer privately with any gentleman who has the leisure and inclination to make the investigation. —Yours, &c., R. SNOWDON.

Staveley, Aug. 22, 1887.

[The letter quoted by our correspondent (and the accuracy of which we, of course, fully maintain) was written in response to a private communication, in which he had expressed his inability to understand how a current could in any case be generated by the motion of a conductor in a uniform field. When Mr. Snowdon states that he is *now* of opinion that "an E.M.F. is *invariably* produced when lines traverse a conductor, whether the number in the circuit changes or not," he goes to the other extreme, and commits himself to an assertion which is capable of easy disproof. Mr. Snowdon's difficulties evidently arise chiefly from a laudable anxiety to obtain a physical conception of the nature of the action which takes place in a conductor traversing a magnetic field. In this desire he has our entire sympathy, although we venture at the same time to think that he will do well to base his working theories upon purely experimental evidence, and to relinquish, for the present, the attempt to understand the *modus operandi* of the generation of E.M.F., at least until something more is known of the nature of magnetism and of electricity. We must, of course, feel very sorry if our reply to our correspondent's letter of twelve months ago has dissuaded him from perfecting any advance either in the theory or the practice of the construction of dynamos; but we must also remind him that his letter said nothing about such a design as he here refers to, but was confined to the query above quoted and to a question about magnetic leakage.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Voice in his last letter correctly states the conditions on which I laid stress in a previous communication, namely, that to produce current by the machine under discussion at the time it would be necessary for the conductors to be relatively influenced by the field; and, indeed, if it were not so, it would be impossible to conceive how two equal and opposing forces could give any dynamic effect. But again I must ask, what does this pivot arrangement prove? The fact of the pivot being cut by fewer lines of force, or if Mr. Voice likes it, by none at all, only presents these conditions with greater force.

Mr. Voice is delighted at the prospect of catching me napping. He says I have clearly contradicted myself; but is there not a little contrariness in the method by which Mr. Voice arrives at this conclusion? Did I not call both the disc and the wires conductors—the former a neutral conductor to distinguish it from the others? Where was the reference to the disc, seeing that there was a full stop between the two sentences? And may I ask why, if there were two possible interpretations, Mr. Voice should be so anxious to take that which would naturally make nonsense?

Mr. Voice then proceeds to set forth a problematical experiment as a subject for discussion. He first informs us he has not tried it, and then winds up by saying "it is impossible to explain the action on the rotating lines of force theory." But what action? Is it an assumed action of Mr. Voice's?

Referring to the two magnets revolving in opposite directions (Fig. 1), he says: "What become of Mr. Thompson's rotating lines of force now? Are they crumpled up, doubled up, or torn asunder like bits of string, or are they infinitely elastic, and capable of unlimited twisting?" But what if nothing of the kind occurs, if the lines of force belonging to the magnet as a whole do not form—that is to say, if the conditions now established are not conducive to the transmission of the magnetic force constituting the greater field—and what if the two separate magnets become in consequence individually stronger?

I put these questions rather as a suggestion than a solution, as I can conceive of two or three other equally probable assumptions, one of which would lead to the production of the stationary field that Mr. Voice is so bent on; but even if this latter were correct, there would be an intelligible reason for such phenomena which could only exist under the very peculiar conditions that Mr. Voice has presented. I do not think that much is to be gained by discussing the problem in question in its present stage, but it will not be difficult to answer Mr. Voice's last interrogatories on the basis of the suggestion I have put forth.

Mr. Voice says:—"Assuming for the moment that the lines do revolve in opposite directions with the magnets (a perfectly feasible assumption under the action described above), how is current generated in this experiment?" I reply that if the magnets were revolving in the same direction, were of identical form and strength, and the discs in symmetrical positions, there would, on my previous showing, be no current, for the simple reason that the E.M.F.'s would be equal and opposed, whereas, on the other assumption, these forces not being equally opposed, current might be expected.

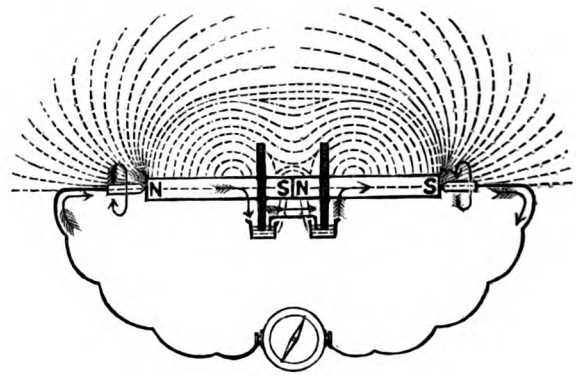

FIG. 1.

Mr. Voice asks, "Where is the fixed conductor that can even remotely be supposed to be cut by any moving lines of force?" I must refer him to the illustration given, which will show him that his bridging wire will be directly cut, and that if the magnets be made to revolve in the directions indicated by the arrows, a current will be set up in the circuit as traced.

Having replied to Mr. Voice's letter, I will now proceed to ask him for some more definite information regarding his own theory. We are still in the dark as to the *raison d'être* of his stationary magnetic field, nor has he told us how, in his opinion, current is produced in any of the machines under discussion. I understand that he will give us this last piece of information in your approaching issue; but what about the field? If Mr. Voice believes that the forces constituting the field of a permanent magnet are maintained, though not caused, by exterior influences, I am quite in agreement; but if he holds that the form and distribution of the field are both due to these influences, I must differ, and my reasons for objecting to such an assumption would be that, inasmuch as a permanent magnet retains the distinctive character of its field in whatever position it be placed, it is evident that any exterior forces capable of effecting this would have to possess not only a characteristic and defined action in accordance with the effect produced, but would have to act in every direction throughout space, whether the magnet be there or not, the result of which would be that these forces would lose their definitive character. We are, then, driven to the conclusion that the form and distribution of the field is a function of the magnet itself, and is dependent on some unknown quality possessed by it, and from this it would follow that in the case of an electro-magnet, when the current ceases to pass round the coils, the iron loses its magnetism because it does not possess that quality by virtue of which the magnetic forces may be maintained under conditions of distribution conducive to their equilibrium. I will further ask Mr. Voice what in his opinion occurs when a permanent magnet is shifted from one place to another? Does the field constituted of molecules under strain or in action move bodily with the magnet, or do only fresh molecules come under its influence?

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If the latter hypothesis were true, each time the magnet was shifted it would expend force on a new field of inert molecules, and hence, by continually moving it backwards and forwards it would very soon lose all its magnetism. Again, if it be assumed that its force is derived from an external source, how is it that magnets do gradually lose their magnetism even when stationary?

But there are other technical difficulties attending such a theory. A conductor moved across the end of a permanent magnet would cut a stationary field, just as I conceive it ought to do; but if the magnet be moved instead of the conductor a different action would result, the molecules of the conductor would not in this case be cut by the field, inasmuch as the field conceived in the material sense would not move, hence the conductor would only be subjected to a strain varying with the intensity of the passing field, and if this field were of even strength or symmetrical, as in the case of a disc machine, the molecules of the conductor would not receive their necessary oscillations.

I will now apply the foregoing to Mr. Voice's theory of an independent field. Let us take an ordinary magnet and place it at A (Fig. 2), as shown. Now, if it be moved to B it is evident that as the field moves with it its motion must be due to the influence of the magnet, and this influence will be exerted in a transverse direction, as shown by the arrow; but the field itself is in a state of tension, or bound, so to speak, together as a whole—hence the influence referred to has been exerted on all the lines passing through the magnet. How is it, then, that the magnet when revolving axially does not exert this same transverse influence on its field, and so carry it round? Perhaps Mr. Voice will explain.

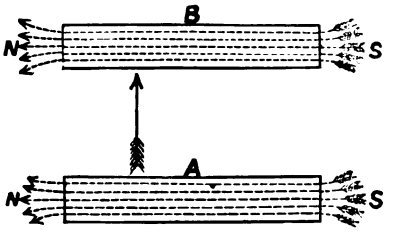

Fig. 2.

I have gone somewhat fully into the question respecting the nature of a magnetic field because Mr. Voice in his last letter stated that it was stationary, and the idea was so inconceivable to me that I had previously—and perhaps without sufficient reason—assumed that his field would not be held stationary by any external conditions, and would consequently be as free to revolve round the magnet as the magnet within it; and this is why I have accused him of asserting in principle the erroneous maxim that the nature of a force can be transformed without the necessary interposing and reacting agent.—Yours, &c.,

N. G. Thompson.

4, Queen Victoria-street, E.C.
Aug. 24th, 1887.

M. MENGES' METHOD OF REGULATING DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your last issue, page 305, you published a note containing some ironical remarks concerning my electric regulating method. The author of this note was apparently very hurried when reading the account of the experiments I made in Paris, for what he said shows clearly that he totally misunderstood my invention.

Firstly, I may assure you that your French contemporaries are not at all "under the impression that this is the only electrical governor in existence;" on the contrary, they know very well that there are a great many electric regulators, and that the apparatus I used is *not* a regulator in the usual sense of the word, because the current to be regulated does not circulate therein.

In respect to myself, I may add that I am perfectly acquainted with Richardson's, Willans', and many other regulators, and therefore I know that all those regulators act only *by means* of the variations in the quantity to be kept constant; therefore they *cannot prevent* variations. By using my method variation may be *prevented entirely.*

Indeed, my method of regulation is quite different to what has been done hitherto; it regulates only in the case of variations in the use of electricity—for instance, when lamps or motors are switched in or out; but irregularities resulting from other causes—for instance, a defect in the dynamo by a short circuit in some coils in the armature—will not be regulated. Now, with a Richardson or any other such electric governor the cause of the irregularity is quite immaterial, and in the supposed case the loss of electric tension will be restored for a few moments by an increased speed of the engine till the armature is completely burned, while had my regulator been used the defect would have been detected at once, and the armature saved from completed destruction, and could perhaps have been repaired at little expense of time and money.

Other distinctive features of my regulating method may be found in the April number of the *Elektrotechnische Zeitschrift* of this year (which I send you annexed by book post), where also my very successful experiments made last year at the electro-technical laboratory of Prof. Slaby in Berlin are related.

The best way to prove the value of an invention is certainly by experiments, and if you consider that, even though the idea had only been put into operation in a "somewhat crude form," as is stated in your journal, nevertheless I obtained results which could not be attained before by the best and very complicated regulators (as was duly observed by competent men), you will agree with me that this is the best proof of novelty and usefulness of my regulating method.

By inserting this letter in your next issue you will oblige—Yours, &c.,

C. L. R. E. Menges.

The Hague, 22nd August, 1887.

[M. Menges will see from a Note in another column that the misunderstanding to which he refers did not arise with us, but from the erroneous version which appeared in a French contemporary.—Ed. *E.*]

THE SUPPOSED NEW FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In *The Electrician* for 19th August Dr. Shettle employs the terms "arterial blood corpuscles" and "venous blood corpuscles" (*see* p. 319). These terms are, it is true, in accordance with the language employed by medical men. When the employment of instruments of precision is requisite for the investigation of any delicate scientific subject, surely the employment of precise language is still more requisite in describing any scientific facts. Hence I should have expressed myself in the following language:—

"I ascertained the magnetic power of the blood corpuscles (discs) while in the arteries, which being charged with greater amount of oxygen gas, and less carbonic acid gas, than the self-same blood corpuscles while in the veins; and proved that the blood corpuscles (discs) while in the arteries are paramagnetic to the blood corpuscles while in the veins—a fact of no inconsiderable importance when it is recognised that the blood corpuscles while in the arteries contain a power to stimulate the nerves to a healthy vital action. This power does not exist in the self-same blood corpuscles while in the veins. These effects are produced through the double exchange of the gases—oxygen and carbonic acid—in the act of breathing, and in the transit of the blood corpuscles, chiefly through those vessels called 'capillaries' in the pulmonary and systemic systems."

I maintain that there are literally and scientifically no arterial and venous blood corpuscles. They are simply blood corpuscles, or discs, wherever they exist, and in whatever condition they occur.

The power to which Dr. Shettle refers is likely to be

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magnetised vital electricity, which permeates the blood corpuscles extracted in the act of inhaling the atmosphere.—Yours, &c., E. Nock.

16, Bloomsbury-street, London, W.C., 20th August, 1887.

THE RISE AND PROGRESS OF TELEPHONY IN THE UNITED KINGDOM.

(Continued from page 310.)

During the year 1881 the United Telephone Company were busily engaged in the work of extending their operations both in London and in the provinces. By this time the value of telephonic communication was fully recognised in commercial circles, and no difficulty was found in establishing subsidiary companies in various provincial centres. As we intend in the course of this series of articles to give an account of each of these in turn, we shall confine ourselves for the present to the history of the parent company.

In face of this manifest proof of the growth and vitality of the telephone it was almost inevitable that attempts would be made to contest the validity of the patents held by the United Telephone Company, or else to show that equally good results might be obtained by means which were presumed to lie beyond the scope of these patents. The first action for infringement was brought in the Edinburgh courts in January, 1882, against a defendant named M'Lean, who had made and sold both carbon transmitters and Bell receivers. Inasmuch as the whole case was virtually retried in the English Courts a little later, it will be sufficient for the present to state that both the Edison and the Bell patents were fully sustained, and an injunction was granted against the defendant.

A more serious attack of the same nature was made in the years 1881-2 by a company which established itself in London and commenced to develop an exchange service under the title of the London and Globe Telephone Company. The instruments adopted by this company were manufactured by Messrs. Harrison, Cox-Walker and Co., and consisted of a receiver identical with Bell's, except that a horse-shoe electro-magnet was substituted for the permanent bar magnet, and a transmitter devised and patented by the Rev. J. Hunnings.

Mr. Hunnings commenced to experiment upon telephones immediately after the British Association meeting of 1877, and carried out his investigations upon a line stretching between his own house and the Archiepiscopal Palace at York. Having failed to obtain any satisfactory results from a diaphragm carrying a point which pressed upon a metallic contact somewhat after the Reis type, he succeeded in the following April in transmitting speech by means of a row of cinders, nearly two feet in length, taken from the fire grate. Prof. Hughes communicated the results of his researches on the microphone to the Royal Society on the 9th May, 1878.

A little later, Mr. Hunnings had found that good results were obtained by the use of a quantity of granulated (not finely powdered) carbon in the form of engine coke, and he placed a layer of such particles upon a substantial brass plate covering them with a diaphragm made of platinum foil. "The reason," says Mr. Hunnings, "that I made use of this oven-made engine coke was because, taken bulk for bulk, its specific gravity was the lightest thing I could find so that sound waves could move about these particles very easily." He further insisted at the time upon the necessity of the grains being in "a perfectly loose condition," so that they could be easily shaken about. It is tolerably clear that Mr. Hunnings's own idea was that the action of the instrument was due to the variation in the number of the grains in electrical contact, as well as in what may be called the average extent of such contact of the several grains. Stress was laid upon this as distinguished from the "pressure" theory of Edison's instrument.

To Hunnings, in fact, as to Berliner, and in some degree to Du Moncel, is clearly due the credit of having constructed what were virtually microphones independently of the researches of Prof. Hughes, but to Hughes alone belongs the honour of having investigated and developed the singular virtues of loose electrical contact. Hughes was the indisputable discoverer of the essential requirements of microphonic action, even although the true theory of the nature of that action is still a matter of dispute.

Before proceeding with the story of the fortunes of the Hunnings transmitter in the hands of the Globe Company, this may not be an unsuitable place to discriminate also between the microphone of Prof. Hughes and the earlier "tension-regulater" of Edison, more especially as the Hughes microphone was scarcely mentioned in the legal proceedings which ensued *re* the Hunnings transmitter. It is frequently supposed that Edison employed the word "tension" in its mechanical sense as having something to do with the elasticity of the diaphragm which forms an essential portion of his instrument. In reality the term is employed in the somewhat loose electrical sense which was in vogue at that period, and was intended to indicate that the apparatus, by varying the resistance of the circuit, regulated, or, more strictly, varied, what we should now call the difference of potential between the terminals of the battery. The following is a description of the device in the words of Sir Frederick Bramwell:—"The tension device is made of something of semi-conductivity, lampblack, plumbago, or other materials *of an elastic character*, which can be brought nearer together, and will re-assert themselves when that which brought them nearer together is removed, and a tympan, or diaphragm, which need not be capable of inductive action—it may be of mica, for example—is caused to vibrate by the sound waves produced by the speaker, and in its vibration varies the pressure on the tension device [which] thereby possesses more or less resistance to the passage of the current." Although, as regards terminology, this language may not, according to our present lights, possess a high degree of scientific merit, yet it is a perfectly clear and unmistakable description of the nature of the device. The essential point here set forth is the use of a conducting material whose resistance by reason of its spongy (rather than elastic) nature* is capable of variation in very exact accordance with the degree of compression to which it is subjected by the sonorous vibration of a diaphragm with which it is in mechanical connection; such material should also be of high specific resistance in order that the total amount of variation in the resistance of the circuit may be sufficiently great for the purpose in view.

But the nature and degree of importance of the part played by the diaphragm in an Edison instrument constructed on these lines is more fully set forth by Edison in the specification of the patent. He says, "Many materials have been employed by me, such as metals, horn, vellum, celluloid, ivory, &c. [it is somewhat singular that he does not mention wood], but almost all of these produce a prolonged or secondary vibration from their own resonant character. *Hence the articulation is defective*, and the sound vibrations blend." [Needless, perhaps, to say that the italics are our own.] He then states that mica is employed, as being almost entirely free from these defects. The principal claim in the specification is as follows:—

"In an instrument for transmitting electric impulses by sound the combination with a diaphragm or tympanum of electric tension regulators, substantially as described, for varying the resistance in a closed circuit substantially, as set forth."

Considering the immense importance which this claim has subsequently assumed and the wide interpretation to which it has been admitted it is a little singular that greater stress has not been laid upon the confession italicised above. Edison certainly did not at the time feel satisfied with the employment of a mere "legal diaphragm;" he required, and to his greater credit he sought until he had discovered, a substance from which a diaphragm having certain specific properties of non-resonance could be made. The microphone of Hughes, upon the other hand, does not require any diaphragm at all, only it happens to be the case that it is somewhat inconvenient and difficult to make use of the apparatus without bringing in at the same time a structure which comes within the legal (though possibly not the scientific) definition of the term. We believe this to be an accurate and impartial

* This description applies to the use of plumbago, as well as lampblack, because the plumbago was applied by being rubbed upon, or dusted over, silk thread or floss, as set forth in the specification.

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version of the evolution of the carbon transmitter, and while we cannot but regret that the generous intention of the discoverer of the microphonic principle has been frustrated, yet we must continue to uphold the necessity of bowing to the decision of the legal tribunals of the country as the ultimate appeal in matters of patent right. At the same time it is a pleasure to quote the language employed by Mr. Preece in a paper read before the British Association, at the Southampton meeting in 1882, and with this quotation we conclude the present chapter. After describing Edison's apparatus, Mr. Preece said :—"Prof. Hughes went a step further. He found a combination of materials that were directly affected by sonorous vibrations, which he called a 'microphone,' and he proved that the effect of the carbon transmitter of Edison was not due to any influence of varying pressure on the mass of the carbon, but was a phenomenon of loose contact. He found a new fact in nature, and he startled the scientific world by introducing an instrument which did for minute sounds what the microscope had already done for minute objects."

(To be continued.)

THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 290.)

In the last paper I unwarily fell into the trap of stating that, under the condition of constant current, μ would be constant, and that therefore the case required no special notice.

This, of course, is not so, because the ratio of the surface to the mass is variable ; the point must therefore be considered.

We have from equation (6)

$$N \propto \frac{E}{R^2}, \text{ that is, as } \mu R^{\frac{1}{2}}.$$

From (7) $A \propto \frac{\mu^2 R^2}{N}$ that is, as $\mu R^{\frac{3}{2}}$, we can thus write

$$A = d_1 \mu R^{\frac{3}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1c)$$

and using square wire,

$$\mu = \frac{\sqrt{A}}{\sqrt{A} + \cdot 05}.$$

Substituting for A,

$$\mu = \frac{\sqrt{d}\,\sqrt{\mu}\,R^{\frac{3}{4}}}{\sqrt{d}\,\sqrt{\mu}\,R^{\frac{3}{4}} + \cdot 05},$$

whence $$\mu^{\frac{1}{2}} = \frac{-\cdot 05 \pm \sqrt{\cdot 0025 + 4\,d\,R^{\frac{3}{2}}}}{2\sqrt{d}\,R^{\frac{3}{4}}},$$

and $$\mu = 1 + \frac{\cdot 005 \mp \cdot 1\sqrt{\cdot 0025 + 4\,d\,R^{\frac{3}{2}}}}{4\,d\,R^{\frac{3}{2}}} \quad . \quad . \quad (2c)$$

Since μ must be less than unity, the negative sign will be taken in (2c). The total work per second will then be

$$W = c\left\{R^{\frac{5}{2}} + \frac{R}{d}\left(\cdot 00125 - \cdot 025\sqrt{\cdot 0025 + 4\,d\,R^{\frac{3}{2}}}\right)\right\}. \quad (3c)$$

In the field-magnets the section of wire is $A = e_1 \mu_1 R^{\frac{3}{2}}$, and with circular wire

$$\mu_1 = \frac{\sqrt{\pi}}{2} \cdot \frac{\sqrt{A}}{\sqrt{A} + \cdot 02}.$$

Substituting for A and solving

$$\mu_1^{\frac{1}{2}} = \frac{-\cdot 02 \pm \sqrt{\cdot 0004 + 2\sqrt{\pi}\,e_1 R^{\frac{3}{2}}}}{2\sqrt{e_1}\,R^{\frac{3}{4}}};$$

whence, by taking the rational sign,

$$\mu_1 = \frac{\sqrt{\pi}}{2} + \frac{\cdot 0002 - \cdot 01\sqrt{\cdot 0004 + 2\sqrt{\pi}\,e_1 R^{\frac{3}{2}}}}{e_1 R^{\frac{3}{2}}} \quad . \quad (4c)$$

The efficiency can now be expressed as a function of B, as before. The length of these expressions might deter many from making any use of them, but the intrinsic usefulness of a means of predetermining the electrical efficiency, especially in the design of very small machines, is undeniable. Nor need the formula here given take any unreasonable time in its application ; in fact, with the assistance of the slide rule or logarithmic tables, a set of curves such as those given in the last paper may easily be calculated in a couple of hours, whilst the systematic use of such curves would afterwards save an immense amount of time and labour.

Before commencing the design of a drum armature machine, it is necessary to correct an error in the original equations on page 479, Vol. XVIII. Here the length of winding was given as

$$2\,N\,R\,(q + \beta + \tau),$$

but the convention was before established that N should not mean the number of complete turns on the drum, but the number of wires counted round the outside ; thus, the above expression should be

$$N\,R\,(q + \beta + \tau),$$

which, followed through, alters the value of R in the ratio of $\frac{1}{2^{\frac{1}{7}}}$, and so reduces the numeric 3 6 to 3·26. There is a further clerical error in the appearance of the symbol π within the brackets in the final equation (4*a*), this quantity being absorbed in the numeric 3·26.

Since in drum armatures the section of the core is greater in proportion to the external dimensions than in rings, it will be best to increase the length in relation to the diameter, as otherwise the field-magnets would work out awkwardly deep, and so increase the coefficient of leakage.

The spindle, being of hard steel, is not considered in the magnetic conductivity of the core. Referring to Fig. 8, page 479, Vol. XVIII., the coefficients will be taken as follows :—

$q = 2 \cdot 5$	$M = 20$
$p = \frac{2}{3} = \cdot 6$	$\gamma = \cdot 8$
$\beta = \cdot 1$	$\rho = \cdot 8$
$\tau = 3$	$\mu = \cdot 8$

Taking, as before, E = 117 volts and C = 100 amperes, we get from equation (4*a*) R = 3·26 × 1·06 = 3·45, say,

R = 3½ inches,
N = 184 = 92 complete turns,
A = ·0262 square inches.

The depth of copper $\mu\beta R = \cdot 276$in., and divided into 2 layers this gives a section ·138in. × ·19in. wide.

The coefficient μ is now found to be $\frac{\cdot 19}{\cdot 19 + \cdot 05} = \cdot 79$, which is sufficiently close to the assumed value. It may be remarked here that the above rule for μ was found to agree with the practical conditions for ring armature winding, where the constant ·05 provides for both insulation covering and for the driving arms of the ring. In drum winding the same constant is retained in order that sufficient space should be provided for the insertion of driving horns at intervals between the windings.

From the number of coils it is seen that a 46 part commutator will be most suitable ; there will then be two complete turns to each section.

The total number of lines passing through the armature is

$$Z_1 = \frac{117 \times 10^6}{184 \times 1000} = 636$$

the saturation coefficient, with M = 20, will be, as before, K = 2·45.

The specific magnetic resistance is

$$R_A = \frac{\pi\left(R - \frac{p\,R}{2}\right)}{p\,q\,\gamma\,R^2} = \cdot 45,$$

thus $K\,R_A = 1 \cdot 4$.

The depth of winding will be $\beta R = \cdot 35$, and by the rule of ⅛in. per foot diameter of core the clearance = ·073, which

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gives $\delta = 423$; but in order to bring this into English measure we will make $\delta = \frac{7}{16} = \cdot 436$in. The magnetic resistance R_a is now to be calculated. Finding the pole surface as before, we get

$$\frac{135}{360} \cdot 2\pi R \cdot q R = 72 \text{ square inches};$$

$$\therefore R_a = \frac{1440 \times \cdot 872}{72} = 17 \cdot 4.$$

The joint resistance $K R_A + R_a$ is thus 18·8, and the exciting power $p_1 = 636 \times 18 \cdot 8 =$ say 12,000.

The air resistance $\rho = \frac{400}{7} = 57$, and the leakage passing under the exciting power 12,000, is $\frac{12000}{57} = 210$, giving $Z_2 = 636 + 210 = 846$. The section of the field cores is thus $AB = \frac{846}{18 \times \cdot 8} = 58 \cdot 8$ square inches.

The length of the armature is $2 \cdot 5 \times 3 \cdot 5 = 8 \cdot 8$in.; the best practical arrangement would therefore be to have two bars, each 4¼in. × 7in., set edgeways, with ⅜in. or ½in. gap between them; the total section would then be 59½ square inches.

To determine the length of the cores μ_1 can be assumed, as before, at ·7; the depth of winding $d = \frac{7}{4} = 1 \cdot 75$in., and the length of a mean convolution $l = 32 + 1 \cdot 75\pi = 37\frac{1}{2}$in., giving the preliminary section A = ·0055. The circular wire corresponding to this section is ·0836in. diameter, which gives $\mu_1 = \cdot 71$.

The number of turns per inch will be

$$n = \frac{\mu^2 d}{A} = \frac{\cdot 503 \times 1 \cdot 75}{\cdot 0055} = 160.$$

Now allowing, say, 3,000 ampere turns for p_2 as a preliminary step, we get P = 15,000—that is, 7,500 on each limb, whence the length of winding is $\frac{7500}{7 \times 160} = 6 \cdot 7$in., say, 7¼in. outside measurement of the case. Setting these dimensions

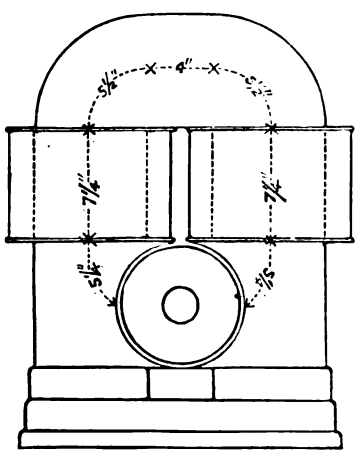

Fig. 15. (One-twelfth full size.)

out in Fig. 15, the mean length of the external field is seen to be 40in. The resistance R_F is thus $\frac{80}{59 \cdot 5} = 1 \cdot 34$, which, multiplied by the saturation coefficient K_2, is $1 \cdot 34 \times 2 \cdot 45 = 3 \cdot 28$, giving $p_2 = 3 \cdot 28 \times 846 = 2{,}780$, whence P = 14,780.

The weights of iron and copper in this machine are as follows:—

Armature core	80lbs.
„ winding	33 „
Field-magnet cores	630 „
„ winding	140 „

the excess over the weight of the ring machine being

Iron	105lbs.
Copper	73 „

On comparison this excess weight is seen to be almost entirely in the field-magnets, and is due to the fact that the nature of drum armatures is such as to offer a large iron section for the passage of the magnetic lines, and to afford comparatively little space for the copper winding; hence the field-magnets must be large in proportion. The weight of the whole is also increased by the use of a smaller heating coefficient ρ in designing the armature.

The electrical resistance of the armature is ·0227 ohm, and the loss in watts $\cdot 0227 \times 10{,}000 = 227$. In the field-magnets the loss is 435 watts. The electrical efficiency is thus $\frac{10000}{10000 + 435 + 227} = 94$ per cent., 1 per cent. higher than in the ring machine.

(To be continued.)

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XLV.

BY OLIVER HEAVISIDE.

Effect of a single conducting bridge on an isolated wave. Conservation of Current at the bridge. Maximum loss of energy in bridge-coil, with maximum magnetic force. Effect of any number of bridges, and of uniformly distributed leakage. The negative tail. The property of the persistence of momentum.

Let a non-distortional circuit be bridged across anywhere by a wire whose conductance is k, and let us examine its effect on a wave passing along the circuit. In the first place, we may remark that we have already solved one bridge problem, viz., the result due to an impressed force in the bridge itself, this being made a special case of the first part of the last Section, by limiting the number of radial circuits to two of the same type.

Now let V_1, V_2, and V_3 be the potential differences in corresponding parts of an incident, reflected, and transmitted wave; V_1 going from left to right on the left side of the bridge, V_2 from right to left on the same side, and V_3 from left to right on the further side of the bridge. At a certain moment these are coincident, viz. at the bridge itself. Then, by the properties of positive and negative waves and elementary principles, we have the following full connections:—

$$\left.\begin{aligned} &V_1 = LvC_1, \quad V_2 = -LvC_2, \quad V_3 = LvC_3, \\ &V_1 + V_2 = V_3, \quad C_1 + C_2 = C_3 + kV_3. \end{aligned}\right\} \quad . \quad . \quad (46d)$$

From these we find

$$-\frac{V_2}{V_1} = \frac{C_2}{C_1} = \frac{k}{k + 2Sv}; \quad \frac{V_3}{V_1} = \frac{C_3}{C_1} = \frac{2Sv}{k + 2Sv}; \quad . \quad (47d)$$

Particularly notice that

$$C_1 = C_2 + C_3, \quad . \quad . \quad . \quad . \quad . \quad (48d)$$

which, though extremely simple, is not by any means obvious at first sight, whilst it is an extremely important property. It is an example of the persistence of momentum; though this may not be immediately recognised, it will be made plain enough later on.

These equations should be compared with (36*d*), (37*d*), the corresponding ones relating to the effect of a resistance r inserted in the circuit. We see that this resistance is replaced by the conductance of the bridge, that L becomes S, and that V and C change places in the expressions for the ratios of the transmitted and reflected waves to the incident.

If we fix our attention upon the current, we see that every element of current, when it arrives at the bridge, is split into two, in the ratio of k to $2Sv$, or of $\frac{1}{2}Lv$ to k^{-1}, half the critical resistance to the resistance of the bridge. The first part is reflected, increasing the current on the left side, and lowering the potential-difference; whilst the other part is transmitted. The electrification in the reflected wave is negative, if that in the incident wave be positive; and conversely.

It may be as well here to remind the reader that from left to right is the arbitrarily assumed positive direction in the circuit, which is the direction of motion of a positive wave (therefore so-called), whilst a negative wave goes from right to left. Also, that the sign of the current, whether positive or

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negative, is a quite different thing. That is, the current in a positive wave may be negative, and the current in a negative wave may be positive, or the reverse. What is a possible source of some preliminary confusion is the fact that the vector we term the current, and the vector direction of motion of a wave, are in the same straight line, one way or the other. These connections are all summed up in $V_1 = Lv C_1$, the property of a positive, and $V_2 = -LvC_2$, the property of a negative wave. If the first of these relations be true, the wave must move from left to right, whether V and C be both positive or both negative; whilst if the second be true, the wave must move from right to left. I can also recommend the reader to take the advice before given to fix his attention upon the electromagnetic field which is implied by a stated V and a stated C, viz.: a field of electric displacement across the dielectric from one conductor to the other, and a field of magnetic induction round the conductors. A very useful purpose may perhaps be served by a careful study of the properties of the non-distortional circuit, viz.: to assist in abolishing the time-honoured but (in my opinion) essentially vicious practice of associating the electric current in a wire with the motion through the wire of a hypothetical *quasi*-substance, which is a pure invention that may be well dispensed with.

Returning to the effect of a bridge, notice that by the union of (48*d*) with the last of (46*d*), we produce

$$2C_2 = kV_3. \quad . \quad . \quad . \quad . \quad . \quad (49d)$$

That is, the current in the bridge equals twice the current in the reflected wave. The corresponding property when it is a resistance r inserted in the circuit that is in question is, by (36*d*), (37*d*),

$$2V_2 = rC_3; \quad . \quad . \quad . \quad . \quad . \quad (50d)$$

that is, the fall of potential through the resistance equals twice the difference of potential of the reflected wave.

If the bridge have no resistance, making a short-circuit (subject to reservations that need not be repeated), there is no transmitted wave. In fact, the case becomes identical with that of a terminal short-circuit, producing total reflection with reversal of electrification. If, on the other hand, the bridge have no conductance, it does nothing. If the conductance of the bridge be $2Sv$, or its resistance be $\frac{1}{2}Lv$, the transmitted wave is half the incident, or the attenuation due to the bridge is $\frac{1}{2}$. Then, by superimposition, the current on the left side is increased in the ratio 2 to 3, and is therefore made three times the transmitted current.

The current in the bridge being kV_3, and the corresponding heat per second divided by v being the heat due to the bridge per unit length of the incident wave, this amounts to

$$kV_3^2/v = 4S^2V_1^2kv/(k+2Sv)^2, \quad . \quad . \quad (51d)$$

by (47*d*). If k be variable, we make the quantity in question a maximum when $k = 2Sv$, which is the above case of attenuation $\frac{1}{2}$. The heat in the bridge per unit length of the incident wave is then $\frac{1}{2}SV_1^2$, which is half its energy; the other half is equally divided between the transmitted and reflected waves.

If this bridge-wire be a coil of a given size and shape, the variation of k implies a variation of the thickness of the wire and of the number of turns. So that, in a well-known manner, the magnetic force of the coil varies as the current in it and as the square root of its resistance; in another form, the square of the magnetic force varies as the product of the resistance of the coil into the square of the current, that is, as the heat per second. Hence, by what has just been said, the magnetic force is also a maximum when the resistance of the coil is $\frac{1}{2}Lv$. Notice that this is the impedance of the circuit as viewed from the coil itself. A correction is required for the inductance of the coil. It ought not, however, to be a very large correction, if it be a telephone that is in question, and of a really good type, having the smallest possible time-constant consistent with other necessary conditions. We require the magnetic force to be a maximum (*i.e.*, due to the current coming from the circuit) to make the stress-variations the greatest possible, and act most strongly on the disc. [*See* "Theory of Telephone," *Electrician*, February 11, 1887.] Allowing for the inductance of the coil, if the currents be sinusoidal, we require equality of its impedance to that external to it, which is the general law.

Now let there be any number of bridges at different parts of the circuit, and let the ratio V_3/V_1 of a transmitted to an incident wave be denoted by s, its value being given by (47*d*), separately for each bridge. Let also ρ_1, ρ_2, etc, be the attenuations due to the circuit in the different sections into which it is divided by the bridges, and start with an isolated positive wave V_1 at A, the beginning of the first section. On arrival at the first bridge, it has attenuated to $V_1\rho_1$. What passes the bridge (not what crosses it) is $V_1\rho_1 s_1$, which attenuates to $V_1\rho_1\rho_2 s_1$ on arrival at the second bridge. Then there is another sudden attenuation, to $V_1\rho_1\rho_2 s_1 s_2$, followed by a gradual attenuation in the third section, to $V_1\rho_1\rho_2\rho_3 s_1 s_2$; and so on, to the end of the circuit, at B. The disturbance is then attenuated to $V_1\rho s_1 s_2 \ldots s_n$; where ρ is the product of all the former ρ's, or the attenuation due to the circuit from A to B, and s_n is the last s, belonging to the bridge next to B. If the absorbing resistance Lv be put at B, it will at once absorb the wave just described; but after that there will come dribbling in and be absorbed the dregs of the original disturbance at A, arising from the complex system of small reflected waves due to the bridges across the circuit, much attenuated by the many to and fro journeys. But if there be but one bridge, and the absorbing resistance be put at A, to get rid of the wave reflected from the bridge, then there is no dribbling in at B.

However many bridges there be, there is, by (48*d*), no attenuation of current due to them, when its integral amount is considered, but only a redistribution of current. This exactly corresponds to the absence of any alteration of the total charge by inserting resistances in the circuit. They merely redistribute the charge.

If there be n bridges in the distance x, each of conductance k, the total attenuation produced by them is, by (47*d*),

$$s^n = \{1 + k/2Sv\}^{-n}. \quad . \quad . \quad . \quad . \quad (52d)$$

Now place the bridges at equal distances apart, and increase the number n in the distance x indefinitely, keeping the total conductance constant, $= K_1x$, say. In the limit we shall arrive at a uniform distribution of leakage, K_1 being its conductance per unit length, and the attenuation due to it will be the limit of

$$\{1 + K_1x/2Svn\}^{-n}, \text{ with } n = \infty,$$
$$= \epsilon^{-K_1x/2Sv}. \quad . \quad . \quad . \quad . \quad (53d)$$

This is therefore the attenuation of the nucleus, when an initially isolated disturbance travels through the distance x, due to the extra leakage K_1 per unit length. There is, in addition, the regular attenuation due to the circuit. Disregard this for the present, by letting the circuit have no resistance and no leakage, that is, no leakage before the leakage represented by K_1 was introduced. Then we see that if there be initially an isolated disturbance represented by $V_0 = Lv C_0$, extending through the very small distance a, it becomes, at the time x/v later, removed a distance x to the right, attenuated to (writing K for the leakage conductance per unit length)

$$V = LvC = V_0\epsilon^{-Kx/2Sv}, \quad . \quad . \quad . \quad . \quad (54d)$$

extending through the distance a, with a tail of length $2x$ behind it. This tail is of the negative kind, the electrification being opposite in kind to that in the head, and is such that the line-integral of the current in it amounts to

$$C_0a(1 - \epsilon^{-Kx/2Sv}), \quad . \quad . \quad . \quad . \quad . \quad (55d)$$

because this, when added to the corresponding line-integral for the head, according to (54*d*), makes up C_0a, the initial value of the line-integral.

This tail is, as regards current, of the same shape as the corresponding tail due to resistance, as regards electrification, so its equation may be derived from (45*d*). But I shall consider the tails all together in a later section.

The property involved in (48*d*), which leads to the deduction of (55*d*) from (54*d*), is worthy of notice. It is the persistence (or conservation) of momentum. If a circuit have no resistance, then, as Maxwell showed, we cannot change its momentum, the amount of induction passing through it. This was a linear circuit, with the current of the same strength all round it. Now our example is a remarkable extension of this property. Our circuit is linear and of no resistance, but it has any number of leaks, or conducting bridges, as well as

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what is equivalent to a series of condensers. The current in the circuit may be varied indefinitely in its distribution, but we cannot change its momentum. The line-integral of LC expresses the momentum, but since L is here a constant, of course the line-integral of C cannot change either. This property only continues true so long as there is no resistance bounding the magnetic field; therefore, if the circuit be of finite length, we must not insert resistances at the terminals. For instance, short-circuit at A and B, and we can at once say what will ultimately happen due to any initial distribution of current. It will settle down to uniformity of distribution, *i.e.* making a uniform magnetic field, so that the strength of current will equal the original total momentum divided by the total inductance. There is of course a loss of energy in the settling down, due to the leakage. If the circuit be infinitely long, so that the disturbance can spread out indefinitely, the total energy will decrease asymptotically to zero, in spite of the persistence of the momentum, which indeed tends to zero in any finite length, but keeps its total amount unchanged.

If the circuit have resistance, the *total* momentum decreases according to the time-factor $\epsilon^{-Rt/L}$, whatever be the initial distribution, if it be short-circuited at A and B, or be infinitely long. On the other hand the total charge subsides according to the time-factor $\epsilon^{-Kt/S}$, if the circuit be *insulated* at A and B, or else be infinitely long. The meaning of terminal short-circuit or of insulation may clearly be extended to various other cases not involving loss of charge in the latter case (*e.g.* a terminal condenser) or of momentum in the former, with appropriate corresponding changes in the measure of S or L respectively.

(To be continued.)

THE WESTINGHOUSE TRANSFORMERS.*

It is well known that, in order to avoid heating and consequent waste in electric transformers, the iron must be ample in section and well laminated. It has also been found that the best results are obtained when the coils are entirely surrounded by iron.

In order to make the construction of such coils convenient, Mr. Albert Schmid, of the Westinghouse Electric Company, has designed a form of core which consists of thin plates, each in one piece, which completely surround the coils. The transformer, as it appears with the outer casing removed, is shown in Figs. 1 and 2,

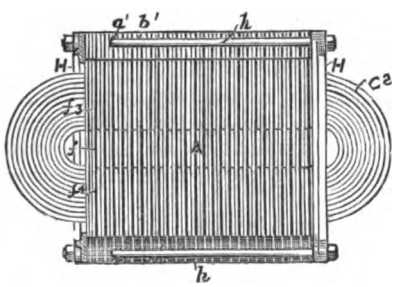

FIG. 1.

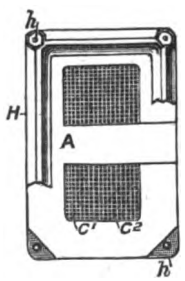

FIG. 2.

and the manner in which it is built up is shown in Figs. 3 and 4. As will be seen, the primary and secondary coils C^1 and C^2 are surrounded by an iron core A, which is composed of thin iron sheets or plates a^1, alternate ones of which are magnetically separated from each other by thin sheets b^1 of paper pasted to the plates of iron.

In preparing the plates a^1, rectangular sheets are stamped with two holes e^1 e^2, which are themselves rectangular in form, and of such size as to receive the primary and secondary coils. Each opening e^1 and e^2 is cut open, as shown at f^1 and f^2, respectively, the cuts being in a line with the inner edges of the corresponding openings. It is not always found necessary to have the cuts exactly in line with these edges; but one or both of them may be in a diagonal direction, as indicated by the dotted lines in Fig. 3. This has the advantage of sharpening the tongue f and making it more easy to insert it in the coils.

The central tongue f extends through the interior of the coils. The separate plates are then applied by springing the portions f^3 and f^4 backward, in the manner shown in Fig. 3, then thrusting the tongue f through the coils and allowing the plate to return to its normal, Fig. 4. The iron used is so thin that the operation may be very readily performed by hand without the use of machinery.

For the purpose of breaking joints the alternate plates a^1 are inserted from opposite side, so that the slits f^1 f^2 of one plate are against the solid portions of the two adjacent plates. The plates are so placed that the bare metallic surfaces of two plates rest against each other, and the opposite insulated surfaces of these plates rest against corresponding insulated surfaces of their contiguous plates.

In building the converter, the plates are temporarily pressed together by clamps. The plates, when as many as practicable have been inserted, are tightly pressed against each other, and to accomplish this two end plates, H and H, are placed at the ends of the converter and bound against the same by four bolts, h, h, h, and h. The plates H and H are of cast iron, surrounding the projecting ends of the coils and resting against the edges of the end plates a^1. To render the completed converter as compact as possible the corners of the plates are cut off to allow room for the bolts.

In running the circuits for distributing the currents by means of converters, the method pursued in a number of instances consists in extending the primary conductors along one set of cross arms of a line of poles, the upper arms, and the secondary conductors along the lower arms. The converters are mounted upon the poles at convenient distances, the primary coils being connected in circuit with the primary conductors, while the secondary coils have their terminals connected with the secondary conductors. The feeders are led from the secondary conductors at the desired

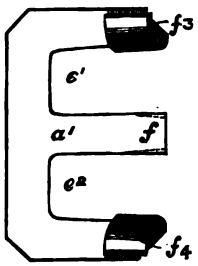

FIG. 3.

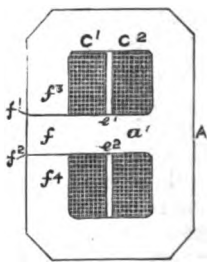

FIG. 4.

points, and the converters are inserted wherever required for maintaining a constant difference of potential throughout the secondary circuit.

* *Electrical World*, New York.

BRITISH ASSOCIATION, 1886.

The following paper, amongst others, was contributed to the last meeting of this Association on various subjects connected with Electrolysis:—

RECHERCHES SUR LA CONDUCTIBILITE GALVANIQUE DES ELECTROLYTES.

BY SVANTÉ ARRHENIUS.

Abstract by OLIVER LODGE. *Remarks by Abstracter in square brackets.*

(Concluded from page 324.)

§ 13. Consequences of the variation of the coefficient of activity and of solubility in heterogeneous systems.

The influence of the variation of the coefficient of activity is much greater for heterogeneous systems in equilibrium than for homogeneous ones. The equation (2A) has the form—

$$(1-x)\,a\,.\,c\,\delta = x^2\,\beta\,\gamma,$$

where c is the quantity dissolved of a slightly soluble or gaseous body, $(1-x)$ the quantity of its conjucate body, and x the dissolved quantity of its opposite. The coefficients of activity are δ, α, β, and γ, respectively.

Let us first examine the influence of pressure.

If the body whose mass is c is a solid, one may reckon that pressure affects nothing, and so—

(45) *A system heterogeneous with regard to a solid is independent of pressure.*

This proposition is in full agreement with fact according to the researches of M. Bunsen (Liebig *Ann.*, T. 65, p. 81. 1848).

If, on the other hand, the c body is a gas, c will be approximately proportional to the pressure *of the gas in question* on the surface of the solvent. So if this pressure is zero, $x=0$. This case is realised if one lets the gas escape from the solvent as fast as it is produced. If the pressure increases, c increases also. For this reason the opposite bodies (whose masses are $x\,\beta$ and $x\,\gamma$) will increase, and the conjugate bodies will diminish. Such a phenomenon has been observed in a lot of cases.

If, for instance, one of the opposite bodies is also a gas, as (for instance) when H_2S acts on an alkaline carbonate, one has the equation—

$$(1-x)\,a\,.\,c\,\delta = c'\,\beta\,.\,x\,\gamma]$$

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By giving to the pressure of H_2S a sensible value, and by separating the carbonic acid which is liberated (*e.g.* by a continual stream of H_2S), one finally arrives at the result that c', and therefore also $1-x$, are zero, *i.e.* that all the carbonate will be transformed into sulphide. *Vice versâ*, by leaving to c' a sensible value, and decreasing c, one could displace the H_2S of an alkaline sulphide by CO_2.

Nevertheless, in the majority of cases the mass of gas dissolved is small in comparison with dissolved other matter. In this case x, that is the quantity of opposite bodies found, will be insignificant, so that the influence of the gas on the system is not notable. Thus, we cannot in general observe changes of equilibrium produced by the presence of gas unless the dissolved quantity of the opposite body is not very small. This case is realised if the body is either gaseous or but slightly soluble, and it has been considered. But also, in the second case, one could perceive the influence of the gas, for the products due to its presence precipitate themselves and disappear from the system. The precipitations of metallic salts by H_2S is a well-known example.

An influence analogous to this of pressure is exerted by temperature if the body with regard to which the system is heterogeneous is solid. The solidity of solids increases with heating. So c and x increase, while $1-x$, the quantity of conjugate body, diminishes. This conclusion has been verified by numerous experiments. One finds many in the works of M. Ostwald, who has studied the phenomena accompanying the solution of some oxalates (CaC_2O_4 or ZnC_2O_4) by an acid. M. Ostwald expresses the said conclusion thus:—

(46) *The influence of temperature on the quantities dissolved by a given acid at constant dilution is always to increase th t quantity.*

Another way of increasing the dissolved quantity c of a slightly soluble body is to increase the volume of the solution (*i.e.*, to add solvent). In this case one increases β and γ also as well as α. At the same time solubility can be diminished by diminution of concentration, as we shall soon see. But in most cases these disturbing influences cannot compensate the increase of c by augment of volume. So—

(47) *An increase of solvent increases the body opposite to, and diminishes the body conjugate to, the solid with regard to which the system is heterogeneous* (if the perturbing influences are not too great).—Ostwald *J. für pract. Chemie* (1881), T. 23, p. 517, and T. 24, p. 486.

[The author then goes on to consider these "perturbing causes." He quotes examples where the solubility of one substance in water has been shown to be increased by the addition of some other salt. He explains this phenomenon on his theory, and holds that the theory of Guldberg and Waage is insufficient to account for it, and, moreover, that it is not in agreement with the numerical results of Ostwald.]

§ 14. Action between Liquids and Solids.

[The author claims even for solids a certain electrolytic conductivity, and hence a certain, though very small, coefficient of activity. It is thus necessary for completeness to consider the action between liquids and insoluble solids. But inasmuch as the activity of even a trace dissolved is much greater, because spread all through a liquid, than the action of a limited area of surface can be, he says the latter may be safely neglected, and states the law.]

(48) *If a system is heterogeneous with respect to a solid body of which, nevertheless, a very small part is dissolved in the surrounding liquid, one can neglect the reactions which occur at the surfaces of contact between liquid and solid.*

§ 15. Velocity of the reactions.

[In accordance with a previous section the velocity with which $I_1 J_1$ and $I_2 J_2$ form (or with which $I_1 J_2$ and $I_2 J_1$ are destroyed), *i.e.*, the velocity of the reaction is—

$$K\,(q\beta \,.\, p\gamma - m\alpha \,.\, n\delta).$$

The author applies this to etherifications, where the water, alcohol, and ether have insignificant coefficients, the acid being the only active body. In this case the velocity is proportional to $\beta\gamma$, and so simply to the activity of the acid used, being quicker with HNO_3 than HA.]

§ 16. Calculation of numerical examples.

The coefficients of activity being not quite constant according to the first part, slightly different numbers must be used for higher concentrations.

§ 17. Conservation of the type, and predisposing affinities.

[Remarks on reactions among non-electrolytes, and on the behaviour of K_4FeCy_6 with reference to Berthelot's hypothesis on "conservation of type" and "predisposing affinities."]

§ 18. Molten electrolytes

should behave just like others.

§ 19. Cases to which Berthollet's laws are not applicable.

M. Berthelot cites some of these cases. They can be put under two general heads. Either a feeble hydrate is unable to displace a stronger hydrate, although one of the products of displacement is but slightly soluble, or a volatile acid (HCl and HNO_3) partially displaces another acid (H_2SO_4), although this acid is not volatile.

The first case is represented by the formula—

$$(1-x)^2\,\alpha\,\delta = x^2\,\beta\,\gamma < c^2\,\beta\,\gamma,$$

where the feeble hydrate and the salt of the strong hydrate are present in equivalent quantites (originally 1), and where c is the soluble quantity of the slightly soluble substance. x is the quantity of this substance formed, but as x is less than c none is precipitated.

One may write the inequality *a fortiori*,—

$$(1-c)^2\,\alpha\,\delta < c^2\beta\,\gamma,$$

or—

$$\frac{c}{1-c} > \sqrt{\frac{\alpha\,\delta}{\beta\,\gamma}}.$$

So if this inequality is satisfied there is no precipitate. α belongs to the feeble hydrate, β to the strong, δ to the salt of the latter, γ to the salt of the former (the slightly soluble substance); $\alpha\,\delta/\beta\,\gamma$ is in general pretty small, so c may be very small and yet no precipitation occur.

As to the second case, no HCl escapes, and so the system is really homogeneous, and a straighforward partition occurs.

We believe we have proved that objections made to the theory of Berthollet are avoided by the theory here presented.

§ 20. Production of heat in chemical reactions.

As we know, M. Thomsen considers that all bases, if they exist in the form of dissolved hydrates, generate the same quantity of heat when dissolved in the same quantity of an acid. This he calls "saline thermo-neutrality." On the other hand, all acids do not generate the same heat when united to a given base—a circumstance which has appeared very odd to thermo-chemists. After what we have just said, however, it appears to me possible to explain it. It is evident that the thermo-chemical parity between the two hydrates cannot obtain unless both are in the active state. In the inactive state analogous compounds do not play the rôle of hydrates (acids or bases), since they cannot unite to a hydrate of any other nature (of contrary sign) and form water and salt. So instead of supposing, as M. Thomsen does, that the hydrates are in a "forme dissoute," we suppose them to be in the active state. After that we put forth the following very natural hypothesis:—

The chemical process, by reason of which a system of one equivalent acid (active) and one equivalent of base (also active), transforms itself into a new system consisting of a salt (not complex) and water, is accompanied by the same heat production independent of the nature of the acid or base.

The different processes which go on during the neutralization of an acid or a base (both supposed partially inactive) are the following:—

1. Neutralisation of the active parts.
2. Transformation of inactive parts into active ones.
3. Neutralisation of these new active parts.
4. Formation of molecular complexes of the salt produced.
5. Possible solidification of the salt.

Between these five processes it is the sum of the heats produced in 1 and 3 per equivalent of salt formed which ought to be constant, according to the above hypothesis.

The existence of the processes 2, 4, and 5 explains how it happens that the actual heat production can be different in different cases.

[Omitting 5, and considering 4 as small, the author points out that No. 2 process is of least importance for strong acids and bases, and accordingly that for these the heat production may really be nearly constant. But for weak acids and bases a good deal of heat is consumed in the No. 2 process. For remember that "strong" means, in his view, "having a high percentage of active molecules," and "weak" means "having very few active molecules." Moreover, since a molecule's activity is allied with, or equivalent to, its dissociation, it is very natural that its production should be a heat-consuming process. Slight residual differences he explains by No. 4 process, considering sulphates and acetates as more complex than chlorides, nitrates, &c., and makes the following statement:—]

(51) *Increase of complexity is accompanied by production of heat.*

(52) *Transformation from the inactive to the active state is accompanied by absorption of heat.*

(53) *During neutralisation a feeble acid or base generates in general less heat on the whole than a strong one.*

Since now for salts it happens that the activity is smaller as the complexity is greater (see § 2), and the formation of molecular complexes is (by 50) followed by a generation of heat, it is necessary that for salts also the transformation from inactive to active state shall be accompanied by heat absorption. But, by prop. 33, bodies endowed with the smallest activity have the greatest chance of being formed. Thus it follows that—

(54) *In chemical reactions among electrolytes those bodies are* in general *formed in greatest quantity, the formation of which is accompanied by the greatest heat production.*

This is the "principle of maximum work," modified. It is valid *in general*, not always.

[Neglecting now the above process 4, the author points out that process 2 has two parts, one concerned with the acid only, the other with the base only. Call these 2_A and 2_B. Process 1 and 3 he considers all along as giving a constant thermal effect; and so he splits up the total heat production H by all the processes thus—

$$H - h_5 = (h_1 + h_3) + h_{2a} + h_{2b},$$

and states—]

(55) *The heat produced by the neutralisation of an acid A by a base B (less heat if possible solidification) is equal to a constant,* plus *a term depending on the nature of the acid only,* plus *another depending only on the nature of the base.*

This has been verified by the experiment of M. Thomsen. A table of the heats of formation of some salts from the results of Berthelot and Thomsen are given. It is on such numbers as these that the rule of Thomsen is founded.

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Heats of Formation of some Salts in Dilute Solutions.

—	HCl	HNO_3	Acetic	Formic	½ Oxalic	½ H_2SO_4	½ H_2S	HCy	½ CO_2
NaOH	13·7	13·7	13·3	13·4	14·3	15·85	3·85	2 9	10·2
KOH	13·7	13 8	13·3	13·4	14·3	15·7	3·85	3·0	10·1
NH_3	12·45	12·5	12·0	11·9	12·7	14·5	3·1	1 3	5 3
½ $CaHO_2$	14·0	13·9	13·4	13·5	18·5	15·6	3·9	—	9·8
½ $BaHO_2$	13 85	13·9	13·4	13·5	16·7	18·4	—	—	11·1
½ $SrHO_2$	14·1	13·9	13·3	13·5	17·6	15·4	—	—	10·5

§ 21. Heat of Activity.

This is the name given to the heat used in transforming a body from inactive to active state.

Now, if an acid unites with a base one can regard the process as the displacement of a feeble acid (water) from its salt (basic hydrate) by a stronger acid. Then, if every substance concerned were perfectly active, the heat of neutralisation of water ought to be the same as that of the strong acid, according to the hypothesis at the beginning of last section, and so no heat production should result from the interchange. But if the water, as fast as formed, passes into an inactive state, its heat of activity will be set free. In fact, it is necessary to suppose that water, immediately after its formation, is perfectly active, for it is formed by the collision of two ions H and OH, endowed with movement. But this activity is instantly lost, and almost inactive ordinary water results. Thus we have shown that—

(56) *The heat of neutralisation, set free by the transformation of a perfectly active base, and acid into water and simple salt, is only the heat of activity of the water.*

One might call this *the thermoneutrality of perfectly active electrolytes.* It is intimately connected with the Williamson and Clausius hypothesis. For as it is reckoned, by this hypothesis, a fair chance whether an iron encounters a similar or a dissimilar one, no work can be done by mere interchanges of ions.

Inactivity of salts is founded on complexity, and to make them more active one must split up molecular complexes. Inactivity of hydrates is caused by more or less disaggregating the molecule into its ions. Either process consumes energy. Elevation of temperature partly effects the process and does the necessary work in liquids, though not in solids, for solids have no appreciable activity even when warm. So it is natural to expect that the specific heat of a substance in the liquid state should be decidedly greater than in the solid state, at least for electrolytes.

For elements and non-electrolytes one would expect the difference to be less marked.

Table of atomic heats in liquid and solid states to confirm this :—

Atomic Heats.

—	Solid	Liquid	—	Solid	Liquid
Bromine	13·3	18·1	Tin	6·5	7·5
Iodine	13·7	27·5	Bismuth.....	6·4	7·5
Phosphorus	11·8	12·7	Water.....	9·0	18·1
Sulphur	12 8	15·0	KNO_3.....	24·2	33·5
Mercury	6·4	6·7	$NaNO_3$	23·7	35·9
Gallium	5·5	5·6	$CaCl_2$	37·6	60·1
Lead	6·5	8·3	Phosphate of Soda	14·7	26·7

(The iodine figure seems to need revising.)

Again, when a body melts, if an electrolyte, it becomes partly active, and extra energy is thus required than if it were non-electrolytic ; so we may expect the latent heat of fusion to be in general higher for electrolytes than for elements.

[Table of latent heats of fusion to show this follows, but the difference is not exceedingly well marked, and there are exceptions.]

Most chemists are inclined to imagine a force between different bodies called that of affinity.

On this view the heat produced by chemical processes is the transformation of a potential energy into heat energy. Berthollet, who adheres to such an opinion, was thus conducted to the necessary consequence that chemical compounds have not a constant composition—a result generally admitted to be erroneous (see § 23). Besides, there are other circumstances in favour of the contrary opinion, viz., that the heat produced by chemical processes is analogous to latent heat. Thus, nobody can deny the complete analogy between dissociation (*e.g.* of $CaCO_3$) and the vaporisation of a liquid, after the researches of Deville, Debray, Troost, Isambert, Ditte, Naumann, and others of the same school.

But the above-given theory conducts of necessity to the latter opinion. So it is from this point of view also in agreement with experimental fact.

§ 22. Comparison between some found and calculated numbers.

M. Ostwald has drawn up a table of the values of the coefficients of relative affinity for different acids, taking that of HNO_3 as 1. The definition given by Ostwald of this coefficient coincides perfectly with that of "avidity," given by Thomsen, who has likewise given a table. We reproduce below both these tables together. . . . . Sulphuric and oxalic acids are liable to form double salts which complicate matters a little (§ 10), but at extreme dilution not much, so their numbers vary with concentration (see § 12).

The coefficients quoted are, for want of better, those applicable when no other body is present; but other bodies, if present, diminish them, just as concentration of the same body does. And feeble hydrates which are most affected by concentration are probably most affected by foreign bodies. These feeble hydrates, therefore, may be expected to be really a little weaker than calculation shows.

The determination of avidity has been made by permitting an equivalent of each to share an equivalent of base (usually NaOH) between them ; the rate of the fractions of the base seized by each acid is their relative avidity. Two numbers are calculated for H_2SO_4, one if it does not, the other if it does, form an acid salt. As for phosphoric acid, we have supposed that its acid salt has only one H replaced by a metal—a supposition which ought not to be pressed, seeing the great excess of free acid present in a reaction. The following are the only acids for which there are data enough to calculate from. The base supposed in the calculation is NaHO for HNO_3, HCl, HI and HA, for the others KHO.

The formula used is that of § 10—

$$(1-x)\,(1-n\,x)\,\alpha\,\delta = x^2\,\beta\gamma,$$

where $n=1$, except for H_2SO_4, when $n=2$, and for H_3PO_4, when $n=3$. The following table gives the results :—

Relative Avidity of Acids.

——	Ostwald exp.	Thomsen exp.	Arrhenius calculation.
HNO_3	100	100	100
HCl	98	100	92
HBr	—	89	86
HI	—	79	92
H_2SO_4	50 to 90	49	47 6 to 85
H_3PO_4	—	13	21·7
$C_2H_4O_2$	1·23	3	8·2

Ostwald specially says that his numbers involve considerable uncertainties, so the agreement is sufficient.

§ 23. Review of anterior theories.

Finally the author reviews the theories of Berthollet, Berthelot, and Guldberg and Waage. He points out that many objections to views expressed in Berthollet's essay of 1803 are met and removed by his own theory. He regards these views as true, but as requiring amplification and additional statements which he supplies.

As to Guldberg and Waage, he says their theory develops itself slowly from 1864 to 1879 in three distinct stages. In the first two memoirs they postulate "forces of action" acting between substances, and in the firs. they give the equation—

$$a\,(p-x)^a\,(q-x)^b = a_1\,(p_1+x)^{a_1}\,(q_1+x)^{b_1},$$

where the indices may be quite different ; and they oppose the view of Berthollet that affinity is proportional to mass.

But in this second memoir they put all the indices = 1, and so abandon this ground. But they still continue the hypothetical "forces of action." Arrhenius objects to these forces as incalculable and unnecessary.

In their third memoir G. and W. introduce the idea of a portion only of each body taking part in the reaction, and think of the number of encounters between such active molecules, and so of the velocity of the reaction, as proportioned to their product, much the same as Arrhenius does.

For heterogeneous systems G. and W. think the surface of the solid present exerts an influence ; but A. says it cannot, or it would vary with the extent of surface, which it does not. In § 13, he says, is cited an experiment fatal to the theory of Guldberg and Waage, according to M. Ostwald, but not inexplicable by the new theory.

Résumé.

"In the present part of this work we have first shown the probability that electrolytes can assume two different forms, one active, the other inactive, such that the active part is always in the same exterior circumstances (temperature and dilution) a certain fraction of the total quantity of the electrolyte. The active part conducts electricity, and is in reality the electrolyte ; not so the inactive part. Moreover, we have proved that the necessary consequence of the hypothesis of Clausius and Williamson is that there exist circular continuous currents. In these currents the active parts alone participate.

"The molecules participating in such currents are necessarily decomposed, according to the scheme of double decomposition, and the result is that new electrolytes are formed. On this basis we have built a chemical theory of electrolytes which, deduced from very probable sources, possesses also a high degree of probability. This theory leads to formulæ applicable to chemical processes, formulæ very conformable to those proposed by MM. Guldberg and Waage,* which have been verified by a great number of experiments. We have also pointed out that the results of this theory agree very accurately with the opinions of Berthollet.

"As a provisional hypothesis we have supposed the coefficient of activity equal to the molecular conductivity. The figures calculated on this supposition, and the reactions thus foreseen, agree very well with experimental facts. We have also from this theory deduced a number of electro-

* The probability of the correctness of the theory is increased to a high degree by the fact that in deducing the formulæ given above we ignored completely those of MM. Guldberg and Waage, formulæ of whose existence we had no knowledge before obtaining the work of M. Lothar Meyer (which only happened after the greatest part of this memoir had already been written). Thus we have found these formulæ without any occasion to construct them in some preconceived manner, and guided solely by the theory of Clausius and Williamson, and by the notion of an active and an inactive state of electrolytes. [Author's note.]

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chemical laws, among others the laws of Faraday and Hittorf; as well as, by the aid of the hypothesis, that every electrolyte has a constant composition we have proved the necessity for the existence of equivalent weights of every substance playing the part of an ion (law of Richter). From data on the variations of conductivity and of solubility we have indicated the reason of a number of phenomena which are set up in equilibrating systems, by dilution, by heating, and by addition of foreign bodies. Finally we have, by aid of an hypothesis very probable in the present state of thermo-chemistry, deduced the principal propositions of thermo-chemistry (among others the "principle of maximum work"), propositions which, however, by reason of the mode of their deduction, are not valid in every case, but only "in general." Also we have indicated the nature of chemical energy, as analogous to that of latent heat; an indication with which specific heats, latent heats, and the phenomena of dissociation correspond.

"All these propositions and all these laws are taken from the most different departments of chemical science; but as the theory agrees so well with reality in these different points, it seems probable that it ought to do so also in intermediate regions. Moreover, we have tried to prove that the differences between this theory and that which, after the examination of M. Lothar Meyer, is now the most probable, relate to opinions of the authors of the said theory, which to a deeper examination show themselves unsustainable either from the theoretical or the experimental point of view. We have thus approached more nearly the theory of Berthollet than MM. Guldberg and Waage have done. And this circumstance speaks, we believe, in favour of the above-developed theory. But here are reasons of greater importance. The theory of Guldberg and Waage (still less any other theory) cannot in its present state deduce more than a fraction of the propositions and laws given above. The constants necessary for the prevision of reactions can, according to the new theory, be approximately deduced from other constants known in other branches of science. Some of the propositions given above, and agreeing with fact, are contrary to the theories of MM. Guldberg and Waage. The difficulty inherent in every theory of electrolysis, and also in the hypothesis of Clausius and Williamson in its primitive form, is totally removed by the new theory. As, besides, the theory given above is founded on very probable bases, and is totally free from every hypothesis of an affinity different from physical forces, it is not doubtful, we think, that this theory will be preferred to all chemical theories hitherto published.

"True, one could object that this theory is only applicable to electrolytes, while previous ones have embraced all substances.

"Against this we remark that chemical knowledge is mainly based on the reaction of electrolytes, which seem in chemistry to play the same rôle as gases do in the mechanical theory of heat. For the rest, the idea of an electrolyte has an extent much greater (according to the law of Hittorf) than one is accustomed to attribute to it. Thus, reactions in general seem to manifest a considerable analogy to those of electrolytes, so that one could perhaps in the future enlarge the theory given for electrolytes so as to be, with some modification, available for all substances."

THE LIGHTING OF THE BRITISH MUSEUM.

In the House of Commons on Tuesday last, on the vote of £147,385 for the British Museum,

Mr. Molloy said that he regretted that the expectations which had been raised with regard to the lighting of the Museum by electricity and the admission of the public at night during hours which would suit the convenience of the working classes had not been realised.

Sir J. Campbell urged the expediency of lighting by electricity the natural history department at South Kensington.

Colonel Duncan, as representing the district in which the British Museum was situated, supported the proposed improvements on the condition that the staff was correspondingly increased.

Mr. Jackson believed that the proposed alterations would involve a large addition to the staff and a considerable increase of expenditure annually over and above the large expenditure which would have to be incurred at the outset. He had been in communication with the authorities of the Natural History Museum with the view of extending the hours for admission. The question of lighting, however, was a more difficult one, requiring very careful consideration, which it would receive.

Mr. Labouchere suggested that the British Museum should be lighted by electricity or should be opened on Sundays.

Sir R. Fowler would oppose Sunday opening of the Museum, but thought that the question of lighting the building in the evening was worthy of consideration.

Mr. W. H. Smith remarked that a reduction of the vote would merely tie the hands of the Government. The question deserved serious consideration, and if the hon. member would be content with the discussion, he would undertake that there should be a careful examination of the facts during the recess. The Government would endeavour to meet the views of Parliament and of the metropolis. There was, however, great responsibility, both as regarded the Exchequer and as regarded the valuable collection in the hands of the trustees.

THE LANCASHIRE AND CHESHIRE TELEPHONE EXCHANGE COMPANY.

Report of the directors for the year ended June 30, 1887, to be presented to the shareholders at the sixth ordinary general meeting of the Company, to be held on Monday, the 29th inst., at half-past 11, at the Memorial Hall, Albert-square, Manchester:—

The subscriptions and rentals (including those of the out-districts) pertaining to the financial year, amount to £82,490. 14s. 6½d. as compared with £72,508. 13s. 2d. for the year ended June 30, 1886. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond 30th June, 1887, is £38,276. 17s. 4d., against £34,681. 1s. 8d. in previous year's balance-sheet. On the past year's working the profit is £28,049. 19s. 3d. After deducting from this sum bank interest, interest on reserve fund, and the interim dividend paid in February last, there remains a balance of £14,212. 11s. 10d. The Directors now recommend a further dividend at the same rate as in February, making a complete dividend of 7 per cent. for the year ended 30th June, 1887. After providing for this dividend

ELECTRICAL TENDERS AT CHICAGO.

The following is a list of the tenders received for the lighting of the river banks and bridges at Chicago. Some account of the character of the work was given in this journal on page 283, and it will perhaps be remembered that about ten miles of cable are to be laid under water. The competition has evidently been very severe, but owing largely, no doubt, to the careful specification drawn by Prof. Barrett, the city electrician, the prices are fairly well together.

	Electric and steam plant.	Cables.	Guaranteed coal consumption per H.-P. per hour.	Amperes.	Volts.	Circuit tension.	Electric plant.	Total cost with 10 miles circuit.
Excelsior, Ide or Payne	$12,745.00	$2,100.00	5·26	10	45	high	...	$34,745·00
F. Wayne Jenney, Williams	...	2,000.00	3·75	20	30	low	...	29,500.00
Brush, Payne	13,560.00	2,350.00	3·25	9½	45	high	$7,760.00	37,060·00
,, Ide	13,182.50	2,350.00	5·	9½	45	high	...	36,682.00
,, Williams	12,847.00	2,350·00	3·75	9½	45	high	...	36,347.00
W. Elec. Co., Russell	11,045.00	1,825·00	4·	18	25	low	...	29,295.00
,, Buckeye	11,399.00	1,825·00	4·	18	25	low	...	29,649.00
,, Williams	11,862.00	1,825·00	3·75	18	25	low	...	30,112.00
,, Payne	12,575.00	1,825·00	3·75	18	25	low	...	30,825.00
U. S. Co., or Williams	14.575.60	1,999·00	5·00	18	30	low	...	34,565.00
Cowle & Van Denburg. (Sperry system)	Electric plant only.		...	...	...	...	6,500.00	...
Cni. Arc. L. & Power Co., Buckeye	...	...	4·5	...	...	high	...	35,000.00
S. S. Badger	...	...	...	96	45	high	7,457.00	...
Ball Elec. L. Co., Payne	15,500.00	2,394.00	3·25	8 to 10	45 to 48	...	...	39,440.00
,, Buckeye	14,100 00	2,394.00	4·	8 to 10	45 to 48	...	...	38,040.00
,, Reynolds	15,900.00	2,394.00	3·⅜	8 to 10	45 to 48	...	...	39,840.00
,, Williams	14,700.00	2,394.00	4·60	8 to 10	45 to 48	...	...	38,640.00

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there will remain, at the credit of profit and loss account, a balance of £1,656. 14s. 1d., which it is proposed to carry forward. A dispute having arisen with the United Telephone Company (Limited), in which judgment, now the subject of appeal, was given against this Company, the Directors do not propose to add to the reserve fund (which, including interest, now amounts to £5,400), but to keep the balance of £1,656. 14s. 1d. in hand. The claim in question arises from a difference in the interpretation of a supplemental royalty agreement, and will in any case involve no loss beyond law expense and interest, as the accrued royalty is already provided for in the accounts. The total number of subscribers, on 30th June, 1886, to the various "exchanges" was 3,483, and of private renters, 1,243; this year, at the corresponding period, the figures were 3,788 and 1,347 respectively. The "exchange" and private line orders on the books at 30th June, 1886, and including work not finished, represented a gross income of £76,115. 14s. 8d. On 30th June, 1887, the amount stood at £81,660. 6s. 4d. showing an increase of new business in these two sections to the extent of £5,544. 11s. 8d., exclusive of the trunk-wire and call-office departments, the gross revenue from which is now at rate of £6,500 per annum—an increase at rate of £1,500 a year since last report. In last report it was announced that your Directors were negotiating with a view to the introduction of a new switching apparatus in Manchester, similar to the one which has answered so satisfactorily in Liverpool. These negotiations are now so advanced that the new board will shortly be brought into operation. Advantage is being taken of this opportunity to concentrate into one switch room all the telephone wires at present dispersed over three separate switch rooms in different parts of the city. The retiring directors are Messrs. Robertson and Thompson, who are eligible for re-election. The accounts have been audited by Mr. C. R. Trevor (Messrs. Trevor and Pilling, Manchester), on behalf of this Company, and by Mr. R. S. Blease (Messrs. Blease and Sons, Liverpool), on behalf of the United Telephone Company (Limited). The Company's auditor, Mr. C. R. Trevor, retires, but offers himself for re-election, for which he is eligible.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 12th and 19th inst. amounted to £3,490 and £2,917 respectively.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the two weeks ended August 19th, amounted to £2,950, and £1,614 respectively, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug 24.		Business Done Week Ending Aug. 24. Highest.		Lowest.	
Anglo-American	36½,	37½	37½		34½	
Do. Preferred	60,	61	61		59½	
Do. Deferred	14½,	15½	15		13⅜	
Brazilian Submarine	11½,	11⅜	11½		11½	
Cuba	11⅜,	12½	12⅜		—	
Do. Preference	18,	19	—		—	
Direct Spanish	2½,	3	—		—	
Do. Preference	7½,	8½	8⅜		—	
Direct United States Cable	8⅞,	9⅛	9		8⅞ xd.	
Eastern elegraph	11,	11½	11½		11 1-16	
Do. 6 per Cent. Preference	14,	14½	14⅜		14½	
Do. 5 per Cent. Debentures, 1899	105,	108	107		106	
Eastern Extension	11⅜,	12	12		1 ⅜	
German Union	10½,	11	—		—	
Globe Telegraph and Trust	5½,	5½	5½		5½ xd.	
Do. Preference	13½,	13⅜	13⅜		13⅛ xd.	
Great Northern	13½,	14	13⅜		—	
Indo-European	35,	37	36⅜		35⅜	
Reuter's	7½,	7⅜	—		—	
Submarine	170,	180	170		—	
West India and Panama	⅝,	¾	—		—	
Do. 1st Preference	9,	9½	9 5-16		—	
Western Brazilian	7⅞,	8½	8½		8	
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	104,	107	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	13-16		⅜
Oriental	⅛,	⅜	—		—
United Telephone	11½,	12	12⅛		11 13-16
United River Plate	4½,	5	—		—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	—		—
Do. (fully paid)	3,	4	—		—
Swan	1½,	1⅝	1½		1 5-16
Maxim Weston	⅛,	¼	3-16		—

MISCELLANEOUS.

Telegraph Construction	35½,	36½	36⅜		36½
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	22½		—

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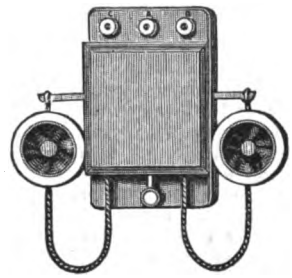
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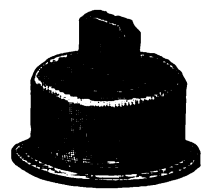
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ELECTRIC Portable SAFETY LAMP.
Ready Light Instantly by simply turning a knob.
Warranted 2½ Hours' Light from one Charge.
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As SIMPLE as with an ORDINARY PETROLEUM LAMP.
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FRAGRANT
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NOTES.

SOUTH AMERICA. — The cable between Chorillos and Mollendo which was broken about a fortnight ago is now repaired.

ALDERNEY.—Direct cable communication between Guernsey and Alderney, which has been interrupted since December last, is now restored.

MONTREAL.—A company is being formed in this city with a large capital for the purpose of providing conduits for the whole of the overhead wires.

CHICAGO.—The contract for the river lighting in this city has been awarded to the Western Electric Company, whose tender amounted to $29,295.

CLUB LIGHTING.—It is stated that during the recess the Carlton Club will be supplied with the apparatus necessary for the purpose of electric lighting. The Athenæum and Junior Carlton are already so lighted.

PONTYPRIDD (WALES).—The guardians of Pontypridd invite tenders for electric bells for the union workhouse. All particulars can be obtained of Messrs. Seward and Thomas, architects, Cardiff. Tenders have to be sent in by the 6th inst.

THE BRITISH MUSEUM.—The electric light is now in operation for the season in the reading room and galleries. The hour of closing is extended to eight o'clock, except for the newspaper room, which will continue to be closed at 6 p.m.

SAN FRANCISCO.—Plans are being prepared for an electric railway about fifteen miles in length in the neighbourhood of San Francisco. The motive power will be obtained from turbines.—A great deal of electric light work is being carried out in California.

CENTRAL AMERICA.—The Central and South American Telegraph Company have obtained concessions from the Columbian Government for a land line to be erected across the isthmus, and for a cable extending from Colon along the Atlantic coast.

PROPOSED UNDERGROUND ELECTRIC RAILWAY.—A company which has just been incorporated in New York proposes to make a tunnel under the East River, to connect Long Island with New York. The tunnel will be five miles in length, and will be worked entirely by electricity.

THE VIENNA OPERA HOUSE.—A fortnight's experience has shown that the electric lighting of the Vienna Opera is a complete success, and, as an evidence of Imperial approbation, Baron Becezny, director of the Imperial Court theatres, has received the Grand Cross of the Francis Joseph Order.

THE AMERICAN CARBON COMBINATION.—It is announced that, owing to the break up of the Cleveland ring, the arc light companies have decided to abandon their intention of forming a mutual carbon manufacturing company. This may be taken as, upon the whole, a satisfactory end of the dispute.

TELEPHONE TENDERS IN SPAIN.—Among the Royal orders published in the *Madrid Gazette* of Friday last, Aug. 26th, are two inviting tenders for the establishment and working of telephones in Granada and in Vigo. Adjudications are to be made on September 27 in the case of Granada, and on September 26 in the case of Vigo.

A NEW SIEMENS MICROPHONE.—Messrs. Siemens Brothers and Co., of Berlin, have brought out (in Germany) a new microphone, in which they have sought to render the surface of contact of the carbons as extensive as possible. Large plates of carbon are employed, and the lower one is suspended by silk threads which pass through a hole in the centre of the plate above.

PITTSBURG.—At Pittsburg there will be in operation very shortly incandescent plant having a total capacity of 53,000 lamps. It is interesting to note that in the boiler rooms the furnaces are heated by natural gas, which by means of regulating valves is completely under the control of the stokers. It is said that if necessary the change from gas to coal can be made in three minutes.

CITY AND GUILDS OF LONDON INSTITUTE.—Some important alterations and additions have been introduced into the programme of Technological Examinations for the year 1887-8. Teachers desiring to form classes should communicate at once with the organising Director of the Institute. A copy of the programme, or 25 copies of any one syllabus, may be obtained by forwarding sevenpence in stamps to the Central Institute, Exhibition-road, London, S.W.

WESTON-SUPER-MARE.—The principal streets of this town were lit by the Thomson-Houston system for the first time on Saturday last. The work has been undertaken through the instrumentality of Mr. Massingham, who, it will be remembered, originated the Taunton Electric Lighting Company. The number of lamps at present in use is twenty-six of 1,200 candle-power; of these, ten are in the streets and the remainder in places of business, hotels, and private residences. There are also upon the same circuit three sets of five incandescents in multiple series.

FATAL ELECTRIC TRAMWAY ACCIDENT AT BLACKPOOL.—On Monday afternoon, as a car of the Blackpool Electric Tramway Company was passing Reid's Baths, a man, apparently about fifty years of age, was observed on the line. The driver shouted to him, but he appeared to become bewildered, and instead of stepping off the line walked in front of the approaching car, which knocked him down, and passed over his legs and the lower part of the body. The driver pulled up, but it was found that the man was quite dead. He proves to have been a Darlington weaver.

SELF AND MUTUAL INDUCTION ON TELEPHONE CIRCUITS.—The *Electrotechnische Zeitschrift* has a paper by J. W. Giltay, in which some experiments upon the effects of self-induction in enfeebling telephonic communication are described. The experiments were more of the nature of demonstrations than of original investigation, and are chiefly devoted to exemplifying the fact that the effects of mutual induction are opposed to those of self-induction because the resultant magnetisation is diminished by the currents due to mutual induction. The practical lesson follows that an electro-magnet in a telephone circuit should either be surrounded by a sheath of copper or should be shunted by a high resistance without self-induction.

AN OIL FILTER.—The Electric Filter Company, of Chicago, have brought out a magnetic filter for cleaning oil which has already been used for lubricating machinery, and enabling it to be used once again. The filter removes the iron particles by means of magnetism. It consists of a vessel contracted in the middle and surrounded at that point by a coil of wire, through which an electric current is caused to circulate. This portion of the cylinder contains iron filings, which are magnetised by the current, and thus attract the iron particles and other metallic particles of magnetic tendency. The oil is further clarified by passing through other filters, such as felt cloths and sawdust, and it is received in a purified condition in the lower receptacle.

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ACID-RESISTING CEMENTS.—An American journal gives the following recipes for the composition of two kinds of cement capable of resisting acid, but not having tried either we cannot guarantee their value :—"A cement for resisting sulphuric acid, even at boiling heat, may be made by melting caoutchouc at a gentle heat and adding, with constant stirring, from six to eight per cent. of tallow. Then mix therewith enough dry-slaked lime to make the whole the consistency of soft paste; finally, add thereto about 20 per cent. of red lead, whereby the mass immediately sets hard and dry. A solution of caoutchouc in twice its weight of linseed oil, aided by heating, and the addition of an equal weight of pipe clay, yields a plastic mass which will resist most acids."

THE ELECTRIC LIGHT AT LEAMINGTON.—During the past week a staff of workmen have been employed laying the final length of the electric light cable in Bath-street. The works in Wise-street are now nearly completed, and it is almost certain the light will be turned on to the town during the month of September. It is stated that nearly all the shops on the line of route have applied for the light to be supplied, whilst the Corporation have contracted for lighting the public buildings and lamps at a cost not exceeding that previously paid to the gas company. The contract is terminable at the year end with six months' notice. With the exception of fittings in the Town Hall and pump room, which the Corporation furnish, the undertaking (a costly one) is wholly borne by the company, who have perfect faith in its success.

MINNEAPOLIS.—At Minneapolis they suspend their arc lamps in the street very much after the fashion in which our forefathers hung their lanterns, on a rope stretching across the narrow streets. They erect two tall posts, one on either side of the road, and the lamp is swung from a rope which passes over a pulley at the top of one of the posts, and descends from thence to a small windlass near the ground. By unwinding the rope from the windlass the lamp is lowered. The wires are attached to the post on the opposite side, and are long enough to allow the lamp to reach the ground. This plan was put into operation some time ago by the Minnesota Brush Company, and has proved very successful. Minneapolis also possesses a tower, or mast light, 270ft. in height, and carrying eight lamps of 4,000 candle-power each.

SALZBOURG.—Messrs. Siemens and Halske have nearly completed the extensive installation which they have undertaken for the Municipality of Salzbourg. The price of one lamp-hour of sixteen candles has been fixed at a trifle under 1d. For arc lamps the following tariff is arranged :—

400 to	500	candles,	2·85d. per hour.
600 to	700	,,	4·27d. ,,
800 to	900	,,	5·7d. ,,
1,400 to	1,600	,,	7·13d. ,,

Arc lamps are only supplied in pairs, or a single lamp is charged as for two. Carbons, if furnished by the company, are charged extra ·66d. to 1·4d. per lamp per hour. A further charge is made for the meters, varying from 25s. for ten lamps, or under, up to nearly £4 for installations of fifty to 100 lamps.

SOLDERING TELEGRAPH WIRES.—M. Prisiajirikov, chief of the Posts and Telegraphs in the Government of Samara, Russia, contributes to a Russian periodical with an unpronounceable name (consisting of 58 letters) a practical note on soldering telegraph wires. In order to lessen the time required for the work, and also to avoid the weakening of the wire from scraping the surface, the author has introduced a method which consists of the use of a heating tool, capable of holding a considerable quantity of melted solder, and upon the top of this is thrown sufficient powdered sal ammoniac to leave a layer of liquid salt of some little depth. This liquid is nearly black in colour. The iron wire already covered with binding wire is then pressed underneath the surface of the melted solder passing through the liquid salt. This effects a perfect solder, no matter how dirty the wire may be.

INSULATED RAIL-JOINTS FOR ELECTRIC SIGNALS.—In a communication to the *Railroad Gazette*, Mr. W. G. Blodgett, electrician of the Boston and Albany Railroad, states that the wooden blocks formerly used for insulating the track sections for the automatic electric block signals were abandoned on the Boston and Albany several years since, because they did not keep the rails well in place, and were not durable. Experiments with vulcanised fibre gave but little better results. The method now in use consists in placing behind the fish-plate a strip of "leatheroid" one-eighth of an inch thick, and moulded to fit the rail. The bolts are insulated from the rails by bushings of the same material, and a piece one-quarter of an inch long, of a size and shape corresponding to the cross-section, is placed between the ends of the abutting rails. The fish plates are planed off to allow for the space taken up by the leatheroid strip.

THE LATEST YANKEE "NOTION."—A recent American patent describes a method of working railways by electricity whereby it is unnecessary to make any change in the type of locomotive already in use. This remarkable result is to be attained in a very simple way. The inventor proposes to remove the tender and replace it by a car containing a storage battery and electro-motor of any usual type. The electro-motor is to be employed in compressing air, which is then forced into the boiler and used instead of steam. We are a little surprised to learn that a locomotive built as a steam engine will work quite as well with compressed air; but doubtless that is a point of detail which has been thoroughly considered by Mr. Jeremiah W. Stoker, of Kansas City. We respectfully commend this account to the consideration of *The Times*, which is just now deeply interested in the subject of compressed air.

ELECTRIC TRANSMISSION OF ENERGY IN MINES.—A somewhat remarkable and, so far, successful application of the electric transmission of energy has recently been carried out in a coal mine near Normanton. The motive power required for pumping water to the surface has hitherto been furnished by compressed air; but the engineers in charge were so dissatisfied with the low efficiency obtained—an efficiency not exceeding 25 per cent.—that they determined to try electric power. The pumps are situated at a distance of about 70 yards from the bottom of a shaft, 300 yards in depth; and owing to the damp atmosphere and confined space the conditions were of a peculiarly trying character for electrical machinery. A second pump is now about to be fixed. When the plant has been a little longer at work, and may be presumed to have reached its final stage of development, we hope to give a detailed account of the whole installation, which our readers will probably find to be of considerable interest.

FLAD'S TOWER SYSTEM.—It will be remembered that at New Orleans it was resolved some months ago to make a bold attempt at a solution of the wire difficulty by adopting a proposal of a certain Colonel Flad. The details of this system have now been more fully worked out, and it appears that at every corner (New Orleans being for the greater part laid out on the chess-board plan) will be erected four posts of malleable iron (one at each angle) 150ft. in height, and, according to the *Western Electrician*, only 7½in. in. circumference. The posts

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run up 40ft. clear of all obstruction, and are then connected by the rods. At the top of the towers will be suspended two steel cables of §in. diameter. Below these, at such a distance as may be required, will be a second pair of steel cables 1in. in thickness, and between these two sets of cables will be strung at intervals of 60ft. "cross-section pieces" of iron or wood, having numerous holes through which the wire will be strung. The contract is now being carried out by the Star Iron Tower Company, of West Wayne, Indiana.

EXTENSION OF LONG-DISTANCE TELEPHONY IN THE MIDLANDS.—Amongst other important extensions of inter-urban telephone lines in the midland counties may be mentioned the following. A trunk line is projected from Nottingham to Derby, thence to Burton-on-Trent and Lichfield, and as a line already exists between Lichfield and Birmingham, this will place Nottingham in communication not only with Birmingham but with the whole of the Black Country district. A second important line is projected from Ilkeston (which is already in connection with Nottingham) to Alfreton, Mansfield, Clay Cross, Chesterfield, and Sheffield. This line will therefore bring the Midlands into direct communication with Yorkshire, and will provide an alternative route to the Lancashire and Cheshire districts. It is further proposed to place the Birmingham centre in direct communication with the Potteries by means of a line from Wolverhampton through Stafford and Stone to Longton, and to provide a second line from Birmingham to Sheffield, *viâ* Hanley, Leek, and Buxton. Lastly, a line is to be built between Nottingham and Leicester.

THUNDERSTORMS. — Heavy thunderstorms were again reported from various parts of the country on Sunday last. Severe thunderstorms raged over the north of Scotland on Tuesday night. At Durness, near Cape Wrath, a house was completely shattered by lightning. The inmates were hurled from the fireside to the door, and were severely injured. On Tuesday, also, at Turriff, Aberdeenshire, Mr. Urquhart, farmer, his son, and two horses, while engaged reaping, were all struck by lightning. On the same evening a severe thunderstorm passed over Buxton. At Dove Holes a house was demolished by lightning, and six persons were struck. One, William Boothby, aged 14, was instantly killed; the others, who were stunned, and lie in a precarious condition, are Mary Ellen Boothby, 20; Joseph Boothby, 13; Sarah Ann Boothby, 10; Joseph Boothby, the father, and his wife. The boy who was killed is badly burned on the body. A man named Lomas, a neighbour, was also stunned. A tall chimney at Bridge Mills, near Warrington, was struck by the lightning, and fell with a crash, doing considerable damage. Damage was also done to the telegraph wires.

ROBERTSON'S WRITING TELEGRAPH.—On Friday, August 26th, the representatives of the press were invited by the Writing Telegraph Company to a private view of this instrument, which has just been brought over from America and is now being shown at a stall in the American Exhibition. The pen of the receiving instrument is attached to an armature capable of motion in the field of a pair of electro-magnets placed at right angles to each other, and the relative strengths of the currents through these coils are varied by the varying pressure excited on two series of carbon discs by a rod, pivoted at its lower extremity, and having its upper end attached to a pen or stylus with which the writing is done. The actual pen of the transmitter is not in mechanical connection with this stylus, but is actuated by it in the same manner as the pen of the receiver. The reproduction is very good, it being almost impossible to distinguish between the slips written at the transmitting and the receiving station respectively. It appears to be a somewhat serious, though apparently unavoidable, drawback to the instrument that it requires a certain amount of practice before it is possible to produce legible writing with it. The instrument is an ingenious one, but is an obvious development of the earlier writing telegraphs of Bakewell and Cowper.

THE MUTHEL DIFFERENTIAL ARC LAMP.—The attempts which have previously been made to construct an arc lamp with two equally inclined carbons have not met with a great deal of success. This principle has, however, such obvious advantages in the way of freedom from shadow and the distance of the arc from the structural supports, that were it not for pure weariness of chronicling the endless modifications of arc lamps, we might be disposed to welcome any renewed attempt giving reasonable promise of success in this direction. The Muthel lamp appears to us to be such an attempt; the principle can be described in very few words. The carbon holders are attached radially to a pair of pinion wheels which gear on either side of the same rack. When the rack descends the carbons are inclined towards one another, when it ascends they are further separated. The pinions are mounted excentrically upon a pair of heavy cams which tend by themselves to bring the carbons together. The rack is fixed at its upper end to an iron core which travels in a double solenoid. The upper half of the solenoid forms a shunt circuit to the lamp, and tends to pull the rack upward, and so bring the carbons together. The lower half of the solenoid is in the direct circuit, and tends to lower the rack and separate the carbons; this is the action which strikes the arc. It is probable that the lamps of this type are better adapted for alternating than for direct currents.

NEW YORK.—During a thunderstorm in New York, one of the arc light circuits on the lower Broadway was struck by lightning and the whole of the lights were extinguished.—The competition for the electric lighting contracts in this city has had the effect of reducing the rate for arc lamps from 70 cents to 25 cents per lamp per night. If the latter is anything like a paying figure—which, however, seems very doubtful—the Brush and the United States Companies, between whom the contract was formerly divided, must have been making a fine thing of it during the last few years.—Not much has been heard of the New York Subway Commission of late; this, perhaps, is in part owing to the fact that its name has been changed to the Board of Electrical Control. The meetings of the Board have recently been the scene of very acrimonious discussions upon the questiom whether, pending the completion of the conduits, the Board should or should not sanction the erection of additional pole lines. One company recently begged permission to erect the modest number of 1,500 poles for electric light cables in the streets. The mayor is vehemently opposed to the erection of any new poles, but for the present he is in a minority on the Board, and in his capacity of chief magistrate of the city he overrules the decisions arrived at by his colleagues. This is all very sad, especially when we remember how kind the Americans were in promising twelve months ago to show us the way to put our wires underground.

ELECTRIC SEARCH LAMP.—During the past week some interesting experiments have been made at Lydd camp with the electric search light. It was desired to work the light under the fire of the rifles and the Gardner guns of an enemy. The engine and apparatus which worked the light were placed under a casemate about 200 yards from where the light was actually seen. The light was so arranged as to be under cover and to throw the rays on to a reflector on the top of a parapet, by means of which the country round was scoured under a

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shower of bullets fired at it. The reflecting disc had a diameter of 26in., and it was found that although it was struck by bullets several times the damage was practically *nil*, the reflecting power being only diminished by the area of bullet holes. The reflector was worked by four temporary guy ropes, divided equally round its surface, two to give depression or elevation and the other two for lateral direction, all these movements being worked from the casemate. The difficulty in shooting at this bright light was found to be very great indeed. Aim could only be taken through a dark piece of oiled paper placed over the foresight. Ten marksmen of the East Surrey Regiment and a Gardner gun were brought to bear upon the light. Several hundred rounds were fired at 1,000 yards and 600 yards. It was found after two hours' sharp firing that the reflector had been struck fifteen times without being seriously damaged. The light was shown at intervals of about a minute only.

Another "Make and Break" Transmitter. — The American National Telephone Company (one of the opponents of the Bell Company in the States) is exhibiting a transmitter devised by Mr. J. W. Bonta, by which it apparently succeeds in proving conclusively that an undulatory current is not essential for the transmission of speech. The Bonta transmitter consists of a diaphragm which carries a carbon pencil projecting from the centre of its hinder face. The point of this pencil just touches a carbon ball about an inch in diameter, which rests loosely in a groove cut in a brass plate. The plate is tilted towards the diaphragm by an adjustable screw, so that when the ball receives an impulse from the pencil it tends to run up the groove and back again. This transmitter is said to give excellent results. When examined through a magnifying glass the ball is seen in action as if continuously separated from the point. In a series of instantaneous photographs which have been secured the two are shown in all degrees of separation. When a light spring was made to bear upon the ball so as to keep it in contact with the pencil, the transmission of speech ceased. It is argued that these facts prove conclusively that speech is, or may be, transmitted "by the succession of currents of uniform intensity and variable duration, and that their varying duration causes the reproduction of the sound." We should like to know, however, whether the "break" is not usually bridged over by sparking.

Electric Lighting in German Provincial Towns.—A correspondent of *Industries* gives the following particulars respecting some installations in Germany:—"The public supply of electricity from central stations is not limited to Berlin only, but is beginning to obtain a footing in various provincial towns throughout Germany. In Hanover there are two small stations already in activity, one for the supply of private customers and the other for the lighting of the Court Theatre. In this case alternating currents and transformers are used, the transmission being by means of an overhead iron wire 100 mils. in diameter, at a potential of 1,200 volts. The total commercial efficiency of the system is 58 per cent. A larger central station with underground cables for the supply of the inner portions of the town is in contemplation. In Magdeburg there is a small central station for lighting a block of houses, including hotels and shops, in the neighbourhood of the railway station, and in addition to this a separate installation for the theatre is now being fitted up. There will be two gas engines of 35 horse-power each placed in an annexe, and the building will be lighted from the dynamos direct. The works of Gruson and Schäffer and Budenberg in Buckau have also special electric light installations. In Brunswick a private person has erected a central station for 1,000 lamps, all the lights being in a block of houses containing business premises. In Dessau, which is the head-quarters of the Continental Gas Company, there is a very interesting installation which has been at work since last year, lighting principally the Court Theatre and the Castle with about 2,000 lamps. Power is furnished by four Otto gas engines, two of them 60 horse-power, and one 30 horse power, working together on a countershaft, from which two 600-light and one 450 light dynamos are driven. The fourth gas engine is an 8 horse-power working a 100-light dynamo, which is used for charging a battery of Khotinsky accumulators, having a total capacity of 600 lamp hours. The cost of the whole installation was about £15,000."

Meeting of the American National Electric Light Association.—This association assembled at Boston on the 9th August, under the presidency of Mr. J. F. Morrison, the meetings being continued throughout the week. The meetings of the association are held twice a year, and this is the sixth meeting since its formation in February, 1885. The previous meetings have been held at the following places in the order named:—Chicago, New York, Baltimore, Detroit, and Philadelphia. The association rapidly assumed the character of an important technical organisation, and its meetings have continuously increased in interest and extent. The following is a list of the papers read, some of which we hope to find room for either in full or in abstract:—"The Electric Light Outfit of the New (American) Cruisers," by Lieut. J. B. Murdock, U.S. Navy; "Silicon Bronze Wire Conductors," address by Dr. Waldo; "The Present Status of the Storage Battery," by Mr. C. C. Mailloux; "On Storage Batteries for Electric Lighting," by Mr. A. Reckenzaun; "On Electric Education," by Mr. Edwin R. Weekes. Most of these papers were followed by animated discussions. The reports of the following committees were also read:—On Electrical Distribution by Alternating Currents; on a Standard Wire Gauge; and on Proper Insulation of Wires and Proper Installation and Construction of Plants. The constitution of the association was also brought under review, and after much discussion certain changes were decided upon. With regard the wire gauge question, we may state at once that it was decided not to make an attempt to enforce any new gauge, but the association recommend that wires be referred to in terms of their diameters expressed as fractions of a metre. The committee on insulation and wiring drew up a programme for an elaborate and exhaustive series of tests with regard to the electrical and mechanical properties of covered wires. It was, however, discovered that the committee had not been authorised to expend any money upon work of this character, and consequently they now tendered their resignation, which was accepted. It is therefore apparently intended to allow the matter to drop for the time being. A very interesting and fairly representative exhibition of various systems of lighting was held in the Parker House, and excursions were made by the members of the association to visit various factories and installations in the neighbourhood of Boston.

University College, Bristol.—This college has been recently enabled to make a notable advance in the matter of engineering education, owing to the generosity of local firms. At a meeting held in the early part of the present year, under the presidency of Albert Fry, Esq., the desirability of instituting engineering scholarships was considered. The practical outcome of this meeting was that most of the firms of the neighbourhood agreed to institute bursaries or scholarships at

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their works. The holders of these are to be nominated by the college authorities. Some will be awarded on the results of the annual examinations, while others will be reserved for deserving students who may be unable to pay the usual premiums required on entrance into works. The educational scheme adopted at Bristol does not include any attempt to impart practical workshop instruction within the college walls; but the students spend six months (April to October) in each year, acquiring practical experience in the works and drawing offices of the engineers of the West of England. This system is found to answer so well that Messrs. Stothert and Pitt, of Bath, and the Bristol Waggon Works Company propose to make it obligatory on all their pupils to attend the college courses in the winter months for the first three years of their pupilage. Several firms have also signified their willingness to take college students for short periods, so that civil engineering and electrical engineering pupils may spend one or two terms of six months in works, while at the same time mechanical engineers may have experience in two or three different establishments during their college career. In return for these concessions the Council of the College has decided to permit deserving apprentices or artisans, nominated by the local engineer, to attend the college courses at reduced rates. It is expected that about nine first class scholarships and a larger number of second class ones will be available during the coming session. The following are the names of the firms which have already put at the disposal of the college authorities one or more scholarship places in their works, on exceptionally favourable terms:—Messrs. Stothert and Pitt, Bath; The Bristol Waggon Works Company, Bristol; Messrs. Cox and Co., Falmouth; Messrs. Newall and Co., Bristol; Messrs. Willoughby Bros., Plymouth; Messrs. Bush and De Soyres, Bristol; Thos. Peckett, Atlas Engine Works, Bristol; Messrs. John Watts and Co., Bristol; Messrs. Spencer and Co., Melksham, Wilts.

Lightning Conductors.—Prof. Tyndall writes from Alp Lusgen to *The Times* of Wednesday last as follows:—"Your recent remarks on thunderstorms and their effects induce me to submit to you the following facts and considerations. Some years ago a rock lighthouse on the coast of Ireland was struck and damaged by lightning. An engineer was sent down to report on the occurrence, and as I then held the honourable and responsible post of scientific adviser to the Trinity House and Board of Trade, the report was submitted to me. The lightning conductor had been carried down the lighthouse tower, its lower extremity being carefully embedded in a stone, perforated to receive it. If the object had been to invite the lightning to strike the tower, a better arrangement could hardly have been adopted. I gave directions to have the conductor immediately prolonged, and to have added to it a large terminal plate of copper, which was to be completely submerged in the sea. The obvious convenience of a chain as a prolongation of the conductor caused the authorities in Ireland to propose it, but I was obliged to veto the adoption of the chain. The contact of link with link is never perfect. I had, moreover, beside me a portion of a chain cable through which a lightning discharge had passed, the electricity in passing from link to link encountering a resistance sufficient to enable it to partially fuse the chain. The abolition of resistance is absolutely necessary in connecting a lightning conductor with the earth, and this is done by closely embedding in the earth a plate of good conducting material and of large area. The largeness of area makes atonement for the imperfect conductivity of earth. The plate, in fact, constitutes a wide door through which the electricity passes freely into the earth, its disruptive and damaging effects being thereby avoided. These truths are elementary, but they are often neglected. I watched with interest some time ago the operation of setting up a lightning conductor on the house of a neighbour of mine in the country. The wire rope, which formed part of the conductor, was carried down the wall, and comfortably laid in the earth below, without any terminal plate whatever. I expostulated with the man who did the work, but he obviously thought he knew more about the matter than I did. I am credibly informed that this is a common way of dealing with lightning conductors by ignorant practitioners, and the Bishop of Winchester's Palace at Farnham has been mentioned to me as an edifice 'protected' in this fashion. If my informant be correct, the 'protection' is a mockery, a delusion, and a snare."

Multiplex Telephony.—Dr. Tommasi, writing in the *Moniteur Industriel*, describes a method of utilising a single wire for the simultaneous transmission of a considerable number of telephonic conversations between distant exchanges. The method is based upon the phenomenon of the persistence of the sensation of sound (analogous to the well-known persistence of the sensation of light upon the retina). That an effect of this character does exist is evident from the fact that we hear musical tones of above 16 (double) vibrations per minute as a continuous sound, and not as a succession of waves such as really exist in the atmosphere. Dr. Tommasi, therefore, proposes to make use of the principle employed in multiplex telegraphy and to cause rotating cylinders to make successive contacts between the several lines which are to be joined, each contact recurring in less than one thirty-second of a second. The cylinder must therefore rotate at a rate of about 2,000 revolutions per minute. It is further necessary that at the opposite end of the single-line wire a similar cylinder be maintained in absolutely synchronous rotation, so that the two cylinders shall always connect the same lines at the same moment. Dr. Tommasi suggests that the first cylinder should be driven by a small electro-motor, and that the synchronism of the second should be maintained "by one of the well-known methods." It is doubtful whether there is any known method by which this can be done other than Delany's adaptation of La Tour's "phonic wheel." In this case (as Dr. Tommasi points out) it will be necessary to run a separate circuit for the performance of this regulation. It must be admitted that the method does not appear very promising, because the make and break of the circuit at the rate of thirty-two times a second will itself give rise to such a noise that we can hardly expect that conversation can be conducted with any degree of comfort, even if it is possible at all. This difficulty seems to us a very grave one; if, however, it can be overcome we should be inclined to anticipate an important future for Dr. Tommasi's device. Only last week we mentioned that there are now twenty-five telephonic circuits in use between New York and Philadelphia, and it is obvious that any method which promises to do the same work with only two circuits is decidedly worth consideration. In the North of England, again, there are several trunk lines upon which (although neither so long nor so heavily wired as the Philadelphia route) the profits are yet nearly all swallowed up in the cost of maintenance. So that here again a reduction in the wire mileage would probably afford perceptible relief. We may add that Dr. Tommasi hopes to find that in practice it may be possible to work at a lower number of revolutions of the cylinder, because it may turn out that the diaphragm of the receiver has, by reason of its elasticity, a tendency to perform a larger number of vibrations than that due to the actual impulses of the magnet.

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THE BRITISH ASSOCIATION MEETING, MANCHESTER, 1887.

[*By Telegraph.*]

(FROM OUR OWN CORRESPONDENT.)

MANCHESTER, WEDNESDAY EVENING.

The annual meeting of the British Association was opened this evening, in the Free Trade Hall, Manchester, under circumstances which promise to make this year's gathering one of the most memorable in the hi story of the association. The vast building was crowded with the largest assemblage of scientific men, perhaps, ever brought together in the United Kingdom, to listen to the inaugural address of Sir Henry Roscoe, M.P., the president for the year.

Prof. A. W. WILLIAMSON, in introducing the president, stated that the retiring president, Sir Wm. Dawson, had sent the following cordial words by telegram from Canada, "Regret inability to personally congratulate the association and Manchester." The learned professor then paid a graceful tribute to Sir Henry Roscoe, referring in warm terms to the eminent services which that gentleman had rendered to the cause of science and learning by his long and admirable work in the formation and development of Owens College and Victoria University.

The PRESIDENT, who was received with the greatest enthusiasm, then delivered his address [a considerable portion of which will be found in our present issue], and during the delivery, which occupied fully an hour and a-half, he carried the audience with him in breathless interest as he reviewed the history and progress of chemical science during the last half century.

At the conclusion of the address the MAYOR of MANCHESTER (Mr. Alderman Harwood) offered on behalf of the City Council and the inhabitants of Manchester a hearty welcome to the members of the association, and moved a vote of thanks to the president for his address.

Prof. GRAY, in seconding the motion, expressed the hope that the present meeting might witness the establishment of an international scientific organisation.

The PRESIDENT, in acknowledging the vote, which was carried by acclamation, said that the figures which had been furnished to him by Sir Douglas Galton showed that the number of members, as well as the amount paid into the credit of the association, was larger than it had been at any previous meeting.

THURSDAY EVENING.

To-day proceedings were commenced in the Physical Section by Prof. BALL, the president, whose address, A Dynamical Parable, was followed by the Report of the Committee on Tidal Observations. Prof. SCHUSTER then read his paper [which we print below], which he illustrated by experiments similar to those given at the Royal Society in June last.

Prof. OSBORNE REYNOLDS addressed the Mechanical Section on the illimitable advance of engineering science.

In the Chemical Section, Dr. EDWARD SCHUNK, president, delivered an address foreshadowing the time when, at the rate at which chemists are now progressing, pure chemistry will be practically exhausted, and be in the same condition as systematic botany and mineralogy at present are.

[Some electrical papers were read, but we are compelled to leave them over.]

EXPERIMENTS ON THE DISCHARGE OF ELECTRICITY THROUGH GASES.*

BY ARTHUR SCHUSTER, F.R.S., of Owens College, Manchester.

Three years ago I gave a sketch of a theory of the passage of electricity through gases, in which it was assumed that in the gaseous discharge an atom carries a definite molecular charge just as in electrolysis (*see* "Bakerian Lecture," Roy. Soc. *Proc.*, Vol. XXXIII., p. 317). I showed how this molecular charge if constant might be measured, and I have since that time worked continuously in arranging for the necessary experiments.

I have, with the help of a grant from the Royal Society, mounted a battery which gives me an electromotive force of 1,800 volts, which I hope will be sufficient for my purpose. The experiments which I have in view involve the accurate measurement of the electric potential at different points of a vessel through which a discharge is passing; but before these could be undertaken a number of intermediate questions had to be settled by experiment. As these have in this way established some definite points which I believe to be of importance, I venture to bring them before the association.

In thinking over the phenomena presented to us in vacuum tubes, I always felt a difficulty owing to our ignorance of the conditions which hold at the surface of bodies, either suspended in or near the discharge, or even at the boundary of the vessel through which the discharge is passing. It is evident enough, that if there is a flow of electricity on the surface of a non-conductor that flow must be tangential, but it is not so clear whether we are justified in concluding from this that there can be no normal forces at such surfaces, for it is not necessary that the flow should always take place along the lines of force. Imagine, for instance, a discharge to consist of particles charging at one pole, then moving, under the action of electric forces, to the other pole; and let the vacuum be sufficiently good that few or no encounters take place while it passes from one pole to another. Then bring an electrified body near the discharge. That body may deflect the particles conveying it, but unless its electrification is sufficiently large, it will not draw up the discharge to its surface, so that the normal forces on the electrified body which has been introduced need not be neutralised by the discharge.

The question is one altogether for experiment to decide. Supposing we suspend two pieces of gold leaf, as in an electroscope, at any place in a partially exhausted vessel, and render them divergent by electrification, they should collapse as soon as the discharge begins to pass, if tangential forces only can permanently exist at their surface. This I have tested by experiment and found to be the case.

A cylindrical glass vessel, 38cm. high and 15cm. wide, was divided into two approximately equal compartments by a vertical metallic screen. There was an open space of about 5 mm. between the screen and the sides of the vessel, a space about 4 cm. above, and 2·5cm. below the screen. One compartment contained two pieces of gold leaf, which could be charged from the outside. The other compartment contained two electrodes about 5cm. apart, and 2cm. from the screen; these distances could be varied during the experiment. The screen was always conducted to earth, and the electric fields on the two sides of the screen were therefore nearly independent of each other. When the gold leaves were electrified and divergent, the discharges from the induction coil passed between the electrodes on the other side, no effect could be observed at atmospheric pressure; the gold leaves remained divergent.

At a pressure of about 4·3 cm. of mercury, the effect I was looking for first appeared; when the discharge passed, the divergent leaves slowly collapsed, and as the pressure was further diminished the collapse took place more and more quickly.

We have here then, even with the discontinuous discharge, a neutralisation of all normal forces at the surface of the gold leaf.

Fig. 1 illustrates in a diagrammatic form the arrangement of the experiment, A and B being the electrodes, S the screen conducted to earth, and E the gold leaf.

In previous experiments, which were not so satisfactory from another point of view, and which I therefore do not quote, the same effects were observed both with the continuous currents from the battery and the discharges from the coil; the only difference being, that the effects due to the continuous discharge were more rapid and regular than those due to the induction coil. As soon as the pressure was sufficiently reduced

* Paper read before the British Association Meeting at Manchester, September, 1887.

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to allow the continuous discharge to pass the destruction of normal forces took place.

It seemed to me interesting to observe more particularly the effects of the ordinary discharges we have at our command, at atmospheric pressure. I took two light balls, and suspended them so that they could be made to diverge by electrification. The electrodes (either spheres or points) of a Voss machine were placed at a distance of 3in. from each other, and the electrified balls were placed at a distance of 9in. from the discharge. The results are contained in the following table, in which the two first columns indicate whether the electrodes of the Voss machine were points or spheres. The third column gives the electrification of the balls, and the fourth column the results :—

Negative electrode.	Positive electrode.	Balls.	Result.
Sphere	Sphere	Positive	Balls collapse slowly.
,,	,,	Negative	,, remain divergent.
Point	Point	Positive	,, collapse quickly.
,,	,,	Negative	,, remain divergent.
Sphere	,,	Positive	,, ,, ,,
,,	,,	Negative	,, collapse slowly.
Point	Sphere	Positive	,, ,, quickly.
,,	,,	Negative	,, remain divergent.

It will be seen that when the two electrodes are similar, whether spheres or points, the balls collapse when they are electrified positively only ; but that when one electrode is a sphere and another a point the balls collapse if their electrification is of the opposite nature to that supplied by the point.

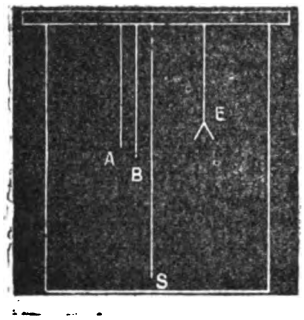

Fig. 1.

I shall refer to the theoretical bearing of these experiments at the end of the present paper, but wish at once to point out that the apparent difference in the results for positively and negatively electrified balls can be one of degree only, and not one of kind. If the balls are positively electrified, they collapse when the two electrodes are similar ; but in the other case, when the balls are negatively electrified, an equal and opposite charge will be found on the objects placed in the room or on the walls. If this positive electricity is neutralised by the discharge, the balls must ultimately collapse in this case, as well as when they were originally positively electrified. To test this argument, I placed the balls in a glass case partially covered on the inside with tinfoil. The inside of the case was nearly a cubical space of sides 37 cm. long. The front of the case was taken out, and the discharge was taken between the two points near the open front. The balls now collapsed, whatever their charge was to begin with, but more quickly when they were positive than when they were negative.

Confining ourselves to the case of a discharge between points and positive balls in its neighbourhood, the question remains whether they will collapse ultimately, whatever their distance from the discharge, or whether there is a finite distance beyond which no effect can be observed, even if the discharge be continued indefinitely. Without wishing to express any final opinion on the point, I may yet give the impression I have obtained from the experiments I have made. I believe that, whenever we have a continuous and steady discharge in an inclosure, however large, the complete neutralisation of all normal forces on surfaces through which no current goes is only a question of time, but that if there is any discontinuity in the currents (as I believe is the case in all discharges at atmospheric pressure) there is a definite distance (depending on the time intervening between two discharges) beyond which no effect will be observed.

The conclusion thus arrived at, which will be proved beyond possibility of doubt in the second part of this paper, is this : *we can only have tangential forces at the surfaces of vessels enclosing a gas through which a discharge is passing*, provided no current crosses the surface. It may be that this conclusion will appear evident to some without experimental proof, but I found it necessary to obtain definite evidence, because the fact itself has been constantly neglected and disregarded.

Thus, for instance, it is found that electrified bodies, placed outside a vessel through which a gaseous discharge is passing, do not permanently affect the appearance of the discharge, and this fact is commonly taken to prove that there can be no free electricity of either kind in the discharge. But it follows from the surface condition at the inside of the vessel, that this surface must act as a complete screen between the electrified bodies placed inside and those placed outside the vessel, and the experiment therefore proves nothing.

In similar fashion, Goldstein observed that certain actions of one negative electrode on another were destroyed when a screen was interposed between them. The results obtained in this paper give the obvious explanation of this fact.

After I had convinced myself that an electrified body placed in a partial vacuum through which an electric current is going has its electricity quickly neutralised, it was doubtful still whether this neutralisation was due to an actual discharge or merely to a covering of electrified particles of an opposite sign. The question is a vital one in all cases where potentials have to be measured. For we can only measure potentials of a gas by measuring the potential of a metal in contact with it, and if an electrified body is covered by electrified particles of a different sign, there is a finite difference of potential between the metal and the gas, and we should have to inquire carefully, in each particular case, how far such a difference would affect our conclusions.

Hittorf has measured with great success the fall of potential at different points of a vacuum tube through which a discharge was passing, and none of his principal conclusions are affected by these scruples, for he gives in his paper sufficient evidence that his method is applicable to the cases he has examined. But the purposes I have in view rendered a measurement of potential necessary under severe conditions, in which a serious error might have been introduced by assuming without verification that the potential of a metal is the same as that of a gas in contact.

Strictly speaking, the potential is always continuous as long as we are dealing with finite charges, but when a layer, the thickness of which extends to molecular distances, has its sides charged with opposite electricity, it is customary to compare the two sides of such a layer directly with each other, and neglecting the rapid variation of potential within the layer, to speak of a discontinuity of potential. It is in this sense that I am here speaking of a possible finite difference of potential between a metal and the gas in contact.

The question is settled by the principal result of this paper :—

A steady current of electricity can be obtained in air from electrodes at the ordinary temperature which are at a difference of potential of one quarter of a volt only (and probably less) ; provided that an independent current is maintained in the same closed vessel.

In other words, a continuous discharge throws the whole vessel into such a state that it will conduct for electromotive forces which I believe to be indefinitely small, but which the sensitiveness of the galvanometer I used has prevented me from tracing with certainty below a quarter of a volt. There cannot be, therefore, a finite difference of potential between a gas and a metal in contact greater than that amount.

Hittorf,* who has done more to clear up this subject than anyone else, has found already that a current from a few cells will pass crossways through a discharge in vacuo, but his auxiliary electrodes were introduced into the discharge itself,

* *Wiedemann Annalen*, Vol. VII., p. 614.

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and it was doubtful, therefore, how far the results were due to the high temperature of the particles carrying the luminous discharge.* I was aiming, on the contrary, at placing the secondary electrodes as far from the main discharge as possible, and at rendering by means of screens the two electric fields as independent of each other as possible.

I need not describe all the successive experiments in which I have endeavoured to make my tests more and more severe. It will be sufficient to give an account of those experiments which I consider most conclusive.

The same vessel was used as in the previous experiment; the screen was not so long, but left a space of 10 cm. free at the bottom. Fig. 2 will explain the arrangement. SS′ is the screen, always conducted to earth; A and B are the electrodes for the main discharge; C and D are the auxiliary electrodes, which were of the form of copper cylinders, 4 cm. high, and having a diameter of 1 and 1·8cm. respectively. Their distance was 2cm., and their axis was 2cm. away from the screen. Of the main electrodes, one was 2cm. and the other 1cm. away from the screen; their distance was about 4cm. The discharge from the battery was always used. Whenever a steady current passed between A and B, an auxiliary battery of Clark cells would send a steady current between C and D, and the lower limit of electromotive force capable of producing a measurable current seemed only to depend on the delicacy of the galvanometer.

Thus, for instance, at a pressure of about $\frac{3}{4}$mm., a current of 0·11 ampere was sent from A to B; and the following currents were obtained when the poles of an auxiliary battery

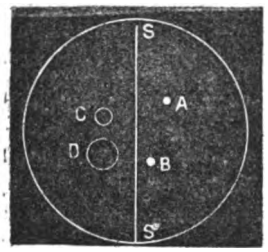

FIG. 2.

were connected with C and D, the galvanometer being inserted in the auxiliary circuit:—

40	Clark cells	0·032	micro-ampere.†
20	„	0·021	„
10	„	0·014	„
1	Leclanché	0·005	„

On another day I tried to reduce the electromotive forces still further. The galvanometer, however, had for this purpose to be rendered so astatic that the always changing torsion of the fibre suspending the mirror was a source of serious trouble; for this reason the numbers have not much value in themselves, but there was no doubt in each case as to the existence of a current. The whole effect was smaller on that day for reasons which could be traced.

1	Leclanché gave a current of	0·0010	micro-ampere.
5/18	„ „	0·0011	„
1/6	„ „	0·0003	„

The main current in these last experiments was 0·008 ampere.

An electromotive force of one-sixth Leclanché is about one-quarter of a volt, and a current has thus been obtained in a gas from an electromotive force which could not maintain a current through water.

An electromotive force of 0·1 volt gave doubtful results, but this was probably due to the experimental difficulty of detecting the current.

In some previous experiments, which, however, were not quite free from objection on other grounds, the lowest electromotive force for which the currents could be measured was 0·2 volt.

The experimental arrangement which is the best for the qualitative investigation of the effect is not the best for quantitative measurements, and I have therefore not endeavoured to follow out to any extent the quantitative laws of these currents produced by low electromotive forces. I may give, however, some facts which I have observed. The intensity of the current depends on a great many circumstances.

1. It increases rapidly with the intensity of the main discharge, and also with a reduction of pressure, as far as I have tried it (that is about $\frac{1}{2}$ mm.).

2. The intensity of the current from the auxiliary battery increases less rapidly than the electromotive force.

3. In some experiments, in which one of the electrodes of the auxiliary battery was a copper wire and the other a copper cylinder, the current was nearly always considerably stronger when the larger surface was the cathode.

4. Anything that facilitates the diffusion of gas from the main current to the auxiliary electrodes will increase the strength of the current observed. In some experiments, in which the screen separating the two fields was made of wire gauze instead of tinfoil, the currents were stronger than those given above.

5. In the arrangement shown in Fig. 2 the currents were stronger when the main electrode A was negative than when it was positive.

Considerable care has to be taken, especially when no screen is used or when it is not conducted to earth, in order to avoid leakage currents. However well the battery may originally have been insulated, the insulation always grows worse with time (owing to dust and moisture). If, then, any part of the auxiliary circuit itself is not properly insulated, we easily get a current through the galvanometer which is nothing but a branch current from the main discharge. Such a leakage current, even when it is weak, considerably increases the effects described in this paper.

These experiments show conclusively that there is nothing peculiar in the gaseous state of a body to prevent any electromotive force, however small, from producing a current. If a finite electromotive force is required under ordinary circumstances the fact cannot be accounted for, as Edlund and others have attempted to do, by a special surface resistance which has to be overcome by a finite difference of potential at the surface.

I think the facts are very well accounted for by the theory which I have proposed in my last paper. If the two atoms of a gas making up the molecule are charged by opposite electricities, but are held together in addition by molecular forces, a finite force is required to overcome the latter. But as soon as that force is overcome and the atoms themselves are set free to diffuse and constitute a current, these atoms will be able to follow any electromotive force which we may apply. If, then, we have auxiliary electrodes, these electrodes will establish their electric field, which we can never screen off completely from any other part of the vessel except by closed surfaces. The atoms, with their positive and negative charges, will diffuse across to the auxiliary electrodes and give off their electricity to them. No finite difference of potential is required in the auxiliary electrodes, because even if there is work done in making an atom interchange its positive for negative electricity, that work is undone again at the other pole, where atoms of a similar kind interchange negative for positive electricity.

This I believe to be the general explanation of the phenomena described in this paper. In order to account for the peculiar difference between positive and negative electricity which appears in the experiments done at atmospheric pressure, also those mentioned under Sec. 5 above, we must make some further supposition. I have already mentioned in my last paper that, according to the theory I have proposed, we must imagine the molecules to be broken up at the negative pole, and I believe that this fact will ultimately be found to account for this apparently unsymmetrical property of the two electricities; but I should like to strengthen my case by further experiment before going into detail on this point.

* That high temperature itself is a matter on which authorities differ. I do not desire at present to commit myself to any view which seems to involve a definition of "temperatures" under exceptional circumstances.

† 1 micro-ampere = 1 ampere × 10^{-6}.

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I should like, in conclusion, to point out an important application of these results. I have last year obtained by calculation results which seem to show that the principal cause of the diurnal variation of terrestrial magnetism is to be looked for in the upper regions of the atmosphere. Prof. Balfour Stewart at various times suggested that the air currents in these regions may, owing to the lines of force of terrestrial magnetism, have electric currents circulating in them.

The difficulty against this supposition always seemed to me to lie in the fact that the electromotive forces required to start a current were larger than those which could possibly exist in the atmosphere. But as there are very likely continuous electric disturbances going on, such as we observe in auroræ and thunderstorms, the regions within which these discharges take place would act as conductors for any additional electromotive force however small, so that any regular motion, such as tidal motions, could very well produce periodic effects affecting our magnetic needles.

If these original discharges increase in importance, then, according to the results obtained in this paper, the currents due to the smaller periodic causes would increase also, and they may increase in a very rapid ratio. We know that the electric discharges in the upper regions of the atmosphere are considerably stronger at times of many sunspots, and this may account for the fact that at those times the amplitude of the daily oscillation of the magnetic needle is considerably increased.

I have had considerable assistance in these experiments from my assistant, Mr. Stanton, to whom my best thanks are due.

In the discussion which followed,

Sir W. THOMSON asked whether Prof. Schuster thought that there was sufficient connection in the atmosphere for carrying discharges so as to render the whole atmosphere conductive.

Prof. SCHUSTER replied that he thought only those particles were conductive through which the discharges actually passed.

EDISON'S PYRO-MAGNETIC DYNAMO.

At a recent meeting of the American Association for the Advancement of Science, Prof. G. F. Barker read a paper by Edison "On the Pyro-Magnetic Dynamo; a Machine for Producing Electricity Directly from Fuel." The following is an abstract:—

"The production of electricity directly from coal is a problem which has occupied the closest attention of the ablest inventors for many years. Could the enormous energy latent in coal be made to appear as electric energy by means of a simple transferring apparatus which accomplishes its result with reasonable economy, it will be conceded probably that the mechanical method of the entire world would be revolutionised thereby, and that another of those grand steps of progress would be taken of which the nineteenth century justly boasts.

"The simple production of a potential difference by means of heat is as old as Seebeck and Melloni. The science of thermo-electricity, thus originated, has been developed by Becquerel, by Peltier, by Thomson, and by Tait, and the thermo batteries of Clamond and Nöe have found many important practical uses. Our fellow member, Moses G. Farmer, worked long and assiduously in this field, producing, it is believed, the most satisfactory results as regards economy which have ever been obtained. But even these results were not very encouraging. He never succeeded in converting 1 per cent. of the energy of the coal into electric energy.

"Quite recently Lord Rayleigh has discussed with his well-known ability the law of efficiency of the thermo-battery from the standpoint of the second law of thermo-dynamics, and he concludes that for a copper iron couple, working between the extreme limits of temperature possible for these metals, a conversion of not more than one three-hundredth part of the coal energy can be hoped for. If, therefore, the result hoped for is to be attained at all, it must be looked for in some other direction obviously.

"It has long been known that the magnetism of the magnetic metals, and especially of iron, cobalt, and nickel, is markedly affected by heat. According to Becquerel, nickel loses its power of being magnetised at 400 degrees, iron at a cherry red heat, and cobalt at a white heat. Since, whenever a magnetic field varies in strength in the vicinity of a conductor a current is generated in that conductor, it occurred to me that by placing an iron core in a magnetic circuit, and by varying the magnetisability of that core by varying the temperature, it would be possible to generate a current in a coil of wire surrounding this coil. This idea constituted the essential feature of the new generator, which therefore I have called a pyro-magnetic generator of electricity.

"The principle of utilising the variation of magnetisability by heat as the basis of electric machines, though clearly applicable to generators, was first applied to the construction of a simple form of heat engine, which I have called a pyro-magnetic motor. A description of this motor will help us to understand the generator subsequently constructed. Suppose a permanent magnet having a bundle of small tubes made of thin iron placed between its poles and capable of rotation about an axis perpendicular to the plane of the magnet, after the fashion of an armature. Suppose, further, that by suitable means, such as a blast or a draught, hot air can be made to pass through these tubes so as to raise them to redness, suppose that by a flat screen symmetrically placed across the face of this bundle of tubes, and covering one-half of them, access of the heated air to the tubes beneath it is prevented. Then it follows that if this screen be so adjusted that its ends are equi-distant from the two legs of the magnet, the bundle of tubes will not rotate about the axis, since the cooler and magnetic portions of the tube-bundle, *i.e.*, those beneath the screen, will be equi-distant from the poles, and will be equally attracted on the two sides. But if the screen be turned about the axis of rotation so that one of its ends is nearer one of the poles, and the other nearer the other, then rotation of the bundle will ensue, since the portion under the screen, which is cooler, and therefore magnetisable, is continually more strongly attracted than the other and heated portion. This device acts, therefore, as a pyro-magnetic motor, the heat now passing through the tubes in such a way as to produce a dissymmetry in the lines of force of the iron-field, the rotation being due to the effort to make these symmetrical. The guard plate in this case has an action analogous to that of the commutator in an ordinary armature.

"The first experimental motor constructed on this principle was heated by means of two small Bunsen burners, arranged with an air blast, and it developed about 700 foot-pounds a minute. A second and larger motor is now about finished, which will weigh nearly 1,500 pounds, and is expected to develop about three horse-power. In both these machines electro-magnets are used in place of permanent magnets, the current to energise them being derived from an external source. In the latter machine the air for the combustion is first forced through the tubes to aid in cooling them, and then goes into the furnace at a high temperature.

"The earliest experiments in the direction of the pyro-magnetic production of electricity were made with a very simple apparatus. The success was such that the construction of a machine of sufficient size to demonstrate the feasibility of producing continuous currents on a large scale in this way was at once begun. This machine is placed upon the top of any suitable furnace, fed by a blast, so that the products of combustion are forced up through the tubes which are not covered by the guard plate, and raise them to a high temperature.

"The potential difference developed by this dynamo will obviously depend (1) upon the number of turns of wire upon the armature coils; (2) upon the temperature difference in working; (3) upon the rate of temperature variation; (4) upon the proximity of the maximum point of effect. Experiments have shown that the guard plate can probably be made to revolve 120 times a minute. Since the potential difference is proportional to the number of lines of force cut per second, it is evident that by doubling the speed or rotation, twice as many lines of force would flow across the generating coils per second and the output of energy would be quadrupled. Exactly what thickness of metal is the more suitable for the purpose; what the relative volume occupied by metal and by air space in the interstitial armature should be; what is the best diameter for this armature, or even the best metal; what the best limits of temperature, and what the best speed of rotation to produce the maximum potential difference—all these are questions which must be decided by experiments made upon the generator itself.

"The results thus far obtained lead to the conclusion that the economy of production of electric energy from fuel by the pyro-magnetic dynamo will be at least equal to and probably greater than that of any of the methods in present use. But the actual output of the dynamo will be less than that of an ordinary dynamo of the same weight. To furnish thirty sixteen-candle lights in a dwelling house would probably require a pyro-magnetic generator weighing two or three tons. Since, however, the new dynamo will not interfere with using the excess of energy of the coal for warming the house itself, and since there is no attendance required to keep it running, there would seem to be already a large field of usefulness for it. Moreover, by using the regenerative principle in connection with it, great improvement may be made in its capacity, and its practical utility may very probably equal the interesting scientific principles which it embodies."

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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REPORT OF THE CITY AND GUILDS INSTITUTE.

Among the many reasons which help us to accept without much regret the loss of the Technical Educational Bill in the present Session of Parliament, not the least is that which is furnished by the Ninth Annual Examination in connection with the CITY AND GUILDS OF LONDON INSTITUTE held last May, and the Report of which is now before us. The objections to the Government Bill, apart from the determining fact that there was not time to pass it, were, firstly, that it proposed to grant further powers of taxation to the School Boards; but chiefly, perhaps, because it placed the whole scheme under the guidance and virtual control of the South Kensington Science and Art Department. Neither of these objections apply to the work of the Institute which we owe to the magnificent liberality and far-seeing wisdom of the City and Guilds of London. The instruction which is being encouraged under their auspices is ostensibly technical, and in the main is of the right kind. And what renders the movement more acceptable is that it is voluntary, and that its success will be a trustworthy measure of the nation's needs and wishes in the matter of technical education—a merit which certainly could not be claimed for the Government scheme, whose conspicuous defect was its setting a sort of premium on the artificial stimulus of South Kensington being applied to fussy and ambitious School Board managers.

It is gratifying to notice year by year the steady progress that is being made with the technological examinations of the City Institute. The subjects in which examinations were held this year have increased to forty-eight, and in thirty of these the number of candidates for examination have risen considerably. The total number dealt with in the May examinations was 5,508, against 4,764 in May last year; and the number of passes has increased in a rather higher proportion. It is fair to predict that, as their sphere of operations is enlarged throughout various parts of the kingdom, the technical schools affiliated with the Central Institute will every year attract a still greater number of pupils. For our own part we have always attached quite as much importance to the Schools as to the Examinations. In this relation we notice with satisfaction that these Schools or Classes now reach the respectable number of 365, and that they extend over 121 different towns; but the number of examinations does not nearly represent the pupils attending these Schools and receiving benefit from their instruction. An increase of nearly a thousand pupils is recorded for the past year, the total number of persons receiving technical instruction in the Registered Classes of the Institute in November last amounting to 8,613.

Now of these little more than half, namely, 4,490, presented themselves for examination, the remaining 1,018 being candidates from London or Provincial colleges not included in the Institute's roll of Classes. We have therefore to face this fact, that the honours and prizes offered by the Institute do not tempt more than about 50 per cent. of the pupils to undergo an examination. It would be rash to draw any inference from this circumstance either adverse to the system of examination or the adequacy of the teaching. We draw no inferences at all; but are content with the growing popularity of the schools, the increased attendance at which is in our judgment a sufficient proof of their practical efficiency. The Examinations are, perhaps, the only way of testing this efficiency to the satisfaction of the Central Institute, but we doubt whether they are a wholly satisfactory criterion of the pupils' progress. It is more to the point that the recent Examinations "were conducted in the Laboratories of Technical Schools (where such were found) or in shops belonging to different firms" of at least one branch of instruction. It would be well if this method could be extended to all other branches; still better, perhaps, if the instruction could be given in such places, instead of in classes "where the scientific principles underlying the work" are principally taught. It is good to teach scientific principles, which no doubt conduce to the acquisition of sound technical knowledge; but if "the results of the Practical Examination were far from satisfactory," as we are told they were, when tested in the workshop, the immediate advantage of the scientific principles are not quite self-evident.

And here we are confronted by the one difficulty which interferes more than any other with the work of technical instruction, whether undertaken by a Society, an Institute, or a Government, away from and outside the practical workshop. This difficulty the Science and Art Department attempts to get over by a broad classification of subjects, which, as Prof. SILVANUS THOMPSON pointed out in his letter to *The Times* on the 15th ult., results in the demand for a little knowledge about many things in place of a thorough acquaintance with the one subject the pupil is concerned with. That is not exactly the difficulty of the City and Guilds Institute; but they have to deal with one hardly less formidable, and which is common to all schemes of the kind alike, namely, the difficulty of giving precisely the instruction needed to the very person who needs it. Tried by this test we very much fear that any and every system of instruction that attempts to take the place of, or to supersede, the old-fashioned system of apprenticeship will partially fail in its object. There will necessarily be a large expenditure of educa-

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tional force which will give no return, except in the general spread of scientific knowledge, and without adding much to the special knowledge among those whom we most desire should possess it. We quite believe that the City and Guilds of London are alive to this fact; and their programme is certainly more hopeful and encouraging than any that has gone before from South Kensington or elsewhere; but it is a long way from attaining their ideal, and we are not quite sure that they are steering on the right track for it.

For one thing, they have not yet made up their minds whether the so-called Technical Instruction shall be mainly technical or largely scientific. At present they try for both, and they will probably not succeed in getting either—or if they succeed with the science it will be at the expense of technology. It is the mistake of the Board Schools over again, only on a higher level. We have more than once confessed our doubts as to what the object of the advocates of technical education really is. If it is to raise the standard of education all round, then, perhaps, they and the Board Schools may be in the right; but if the object is to create a better class of workmen and to improve their workmanship, we rather suspect they are in the wrong. The only useful education is the education that is useful, and it must differ according to the use that is going to be made of it. This we are aware is not a maxim with Board School managers; but we are a little surprised to notice that neither is it apparently a favourite with technological examiners. Mr. W. H. PREECE, for the ninth time, complains that the candidates cannot draw; and so does Mr. J. J. HOLTZAPFFELL. Here is a complaint of the right kind. Day schools ought to teach drawing, whether they teach reading or not. It is imperative a skilled workman should be able to make a drawing; it is not at all imperative he should be able to read the *Gutter Gazette*. But turning to the other Examiners, we notice that they often measure the value of the candidate's answers by the "early education" he displays. And we are left in no doubt as to what this means, for another Examiner deplores the "bad spelling" and "ill constructed" language which show that "the candidates are devoid of the rudiments of ordinary education;" while a third implicitly conveys the idea that he has rejected candidates on those grounds, notwithstanding "the practical knowledge of which in many cases they are unquestionably possessed." We hope this is not an inference to be drawn generally from the remarks of examiners more fastidious than wise in their demands for well constructed language. A *vivâ voce* examination would of course set this matter right. It is perhaps an insuperable defect of paper examinations that the indications of ignorance on the one hand and illiterateness on the other are hard to distinguish, and may easily be mistaken. We offer these criticisms in good part, and with a sincere desire to promote the cause which the City and Guilds of London have especially at heart.

CORRESPONDENCE.

THE FORBES NON-POLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Snowdon in his last letter appears to think that I have not grasped his theory *in toto*. I take it that my definition was correct as far as it went, but that I omitted to include certain important points; and I now gather from his recapitulation that—(1st) I omitted to include the exciting coils, and "that portion of the galvanic circuit which is distinct from the armature, &c.," as sources of retardation to the magnetic field; (2nd) that the E.M.F. generated in the armature and the E.M.F. generated in the stationary conductors outside is the same; and (3rd) that E.M.F. is produced whether there be current or not.

Now, I think Mr. Snowdon would have done well if he had let these pass. In the first place, no current could be produced in the exciting coils, as the field revolving, on his theory, would not cut it in the right direction, and as production of current by the field can be the only cause of retardation we may neglect such influence. Then as to the external circuit, does Mr. Snowdon mean that only that portion of the circuit that is within the field is a cause of retardation? If so, I may tell him that this may also be neglected, inasmuch as these contacts were originally constructed of carbon. I cannot think that Mr. Snowdon intends to imply that the current produced by the armature passing through these contacts is a cause of retardation; but if it does it would only make the electrical efficiency of the machine still worse than I previously stated, for now we should have a portion of the 50 per cent. that I charitably put down to useful effect in the armature wasted in useless action. Again, when Mr. Snowdon asserts that the E.M.F.'s generated in the core and armature would be the same, he states an assumption that could only hold true if the distribution of the field and velocity of cutting were the same in each; but if Mr. Snowdon will look at the longitudinal section of the field in question, as shown in one of his previous sketches, he will see that its lines of force will diminish in intensity in a radial direction from the centre of the exciting coil, and if he inspects the same field transversely—that is, in the line of the axle—he will also see that they converge to the centre of the armature. Putting, then, these two facts together with the radially varying velocity of the field itself—which, by his theory, revolves as a whole—he will understand why the distribution and cutting of that portion of the field that would traverse the core is not quite so simple a matter as it at first appears. But if for argument's sake we assume that the E.M.F.'s are equal, they would by no means be any criterion of the retardation given to the field; such retardation could only be controlled by the relation existing between the current and resistance; and this function is not expressed by E.M.F. alone. Mr. Snowdon will know practically that the more resistance he puts into the armature circuit of an ordinary dynamo, the less will be the field's reaction, and the power required to drive, notwithstanding that the E.M.F. be kept constant. Mr. Snowdon does not seem to have realised the fact that when power is applied, as in his case, to the field, the amount of retardation can only be measured by power opposed, and this when of an electrical nature must be valued by the expression $C^2 \times R$. When Mr. Snowdon says that E.M.F. is induced without current he simply gives infinity to R in the equation $E = C \times R$, and hence there is all the more reason why there should be no retardation. The function of a magnetic field is simply to determine what power can be produced under certain conditions, and this determination rests on the density of its lines and the velocity with which it is cut; but the conditions that control the amount of power actually developed are dependent entirely on the nature of the conductor, considered as a complete circuit. If the resistance of the conductor as a whole is high, its molecules will not attain a high velocity of oscillation; if the resistance is low they will, and greater power will be produced, for very much the same reason that a steam engine may be made to give greater horse-power by altering the gearing so as to permit of greater piston speed.

I must here correct some rather misleading remarks that Mr. Snowdon has thought fit to make on my previous letter. He says, in paragraph 5, "That that something (in which this reaction has its seat) is either the exciting coil (as Mr. Thompson has it), or," &c. Now, I not only never set forth the exciting coil as a cause of the reaction in the letter in question, but I never asserted it to be such in any of my previous letters; and again, further on in the same paragraph, he expresses surprise at my imputing to him that which he had clearly disclaimed, but if Mr. Snowdon had not quoted only a portion of the sentence in question it would have been evident to everybody that this was only a preparatory statement to show

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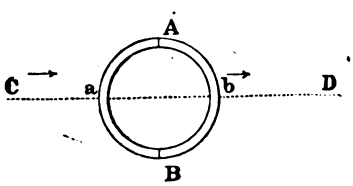
that heat generated as he suggested could not be a significant cause of retardation.—Yours, &c.,

N. G. THOMPSON.

4, Queen Victoria-street, August 31st, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your footnote to my letter you point out that in saying that "an E.M.F. is *invariably* produced when lines traverse a conductor, whether the number in the circuit changes or not," I have committed myself to an "assertion which is capable of *easy* disproof." You will, I know, forgive me if I combat this statement; for, indeed, the very reverse is the fact, and even doctors differ. I might describe an elaborate method of absolute experimental proof, but I believe the following considerations will carry the point:—Suppose the ring A*a* B*b* to move in a direction parallel to the line C D—which line marks the centre of a magnetic field which is supposed to be uniform in the direction of its length—in the place occupied by the ring. x lines of this field pass through the ring, and no change is produced in this number by the motion; for each half A*a*B – A*b*B of the moving ring cuts the same number of lines, and it is a concomitant circumstance that there is no current round the ring. If, now, a conductor which is not touched by the lines of force (A and B may be supposed to lie on the borders of the field) be applied to the points A and B, a current at once circulates from A to B through each half of the ring, and through the outer conductor.



If, under these circumstances, the resistances of the outer conductor be very small, it is well known that only a small electrical pressure can exist at the terminals A and B, but if the outer resistance be gradually increased until it is very large, then, as is well known, the pressure at the terminals gradually increases until it practically reaches the maximum E.M.F. corresponding to the rate at which the ring cuts the lines. Now when the resistance of the external portion of the circuit is practically infinite, the terminal E.M.F. has its maximum value. Use for this portion of the circuit a bent rod of glass—a shocking bad conductor, truly, but still not an absolute non-conductor, and constituting, with the ring, a mathematical circuit—the E.M.F. has not been scared away. Current has, to all practical purposes, ceased, but E.M.F. is at its maximum. Dispense with the glass portion of the circuit, and consider that you have one of air in its place, and you have still maximum electrical pressure.

It is true I did not describe in full detail the non-polar dynamo which is illustrated in to-day's *Electrician*; but I am sure you would recognise the toad-stool field-magnet, and the identity of the principle of the moving systems. I did not state my purpose in asking the information I did for fear of appearing ridiculous.—Yours, &c.,

R. SNOWDON.

Staveley, August 26th, 1887.

[Mr. Snowdon is, we fear, guilty of the logical fallacy of a *petitio principii*. He undertakes to show that an E.M.F. is *invariably* generated when a conductor traverses a uniform field; he then admits, with unaffected candour, that a plane-closed circuit moving through a uniform field parallel to its own plane generates no E.M.F. on itself, but he immediately asks us to upset these conditions by extending the circuit so as to include a portion beyond the (uniform) field. We are not quite sure whether Mr. Snowdon means his ring to move parallel to the lines of force or across them. In the former case we see no reason to suppose that an E.M.F. is necessarily generated even under the second condition of the circuit. In the latter case, without decisive experimental proof, the assertion that the absence of current when the circuit is confined to the ring alone must necessarily be due to two opposing E.M.F.'s can hardly be justified in our present state of knowledge; at the best, the argument is reduced to a verbal quibble, in which we should be perfectly willing to yield our correspondent the victory.—ED. *E.*]

ARC LIGHT PROJECTORS IN THE ROYAL NAVY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a note in your issue of last week you ask if any good reason can be advanced for the continued use of hand, in preference to automatic, regulation for arc light projectors in our navy.

I write to state a few arguments in favour of the former system, and I may say that my experience with projectors has been derived during several years at sea on board of warships with both types of lamps.

A well known trouble with arc lamps using heavy currents, and consequently large carbons, is the excessive tendency to "mushroom," and this even with the very best quality of carbon. Although the services for feeding the arc are now very perfect, I am unacquainted with any arc lamp adapted for heavy currents which would automatically open an arc which had been closed or "throttled" by "mushrooms."

Again, the irregularity in the consumption of carbons caused by this "mushrooming" constantly destroys the focus even of the most perfect automatic lamps. On the other hand, a little practice with the hand regulator will enable the blue jacket easily to keep the focus perfect.

The rolling of the ship, or the shock caused by the firing of guns, not only seriously affects the feed of the automatic lamp, but often completely disarranges its apparatus.

As the projector is often placed in a position where it is much affected by the vibration of the ship, a very rigid lamp is essential. It will be admitted that no automatic lamp can compare with the hand regulator for rigidity. Its parts are very simple, and may easily be repaired or replaced by a ship's artificer.

Regarding the objection to the hand regulator, that it gives the man in charge a double duty, it has not been my experience that the blue jacket in charge of the projector considers his duty either difficult or oppressive.

The coloration of the beams from the projectors during the recent naval evolutions would seem to indicate that the carbons used were not of a high quality, or that some of the attendants were not sufficiently instructed.—Yours, &c.,

ALFRED MAYOR.

Forth Bridge Works, South Queensferry, N.B.,
August 29th, 1887.

THE SUPPOSED NEW FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be obliged if you will find me space in *The Electrician* to thank Mr. Nock for his remarks and very concise enunciation of his views. I will endeavour, as far as possible, in the future to render my meaning clear to physicists as well as physiologists.—Yours, &c.,

RICHARD C. SHETTLE.

London-street, Reading, August 30th, 1887.

THE VAN RYSSELBERGHE SYSTEM.

The *Bulletin* of the Belgian Society of Electricans contains an interesting communication on the Van Rysselberghe system of simultaneous telegraph and telephone communication, showing the extent to which the system is at present in use. The first experiments were carried out by Van Rysselberghe on the line between Brussels and Paris in the month of May, 1881. A more complete set of experiments were made in the following year between Brussels, Antwerp, and Ostend; but the first practical use of the system was on the line between Amsterdam and Haarlem, a distance of 20 kilometres. This line was opened for the public service on the 27th October, 1883. In the same year the Belgian Chambers passed a vote authorising the application of the system to the existing telegraph lines. It was not, however,

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until the autumn of the following year (1884) that the first Belgian line (between Brussels and Antwerp) was finally opened for public service.

Since that time thirty-seven circuits of this nature have been established in different parts of the country, showing a total length of 7,206 kilometres of wire; and it appears that there are in Belgium only 260 kilometres of inter-urban telephone lines which are worked independently of the telegraph. In France the first line was opened on January 2, 1885, between Rouen and Havre. There are now seven lines equipped upon this system, namely Rouen-Havre, Rouen-Louviers, Paris-Reims, Paris-Rouen, Paris-Havre, Paris-Lille, Paris-Marseilles. The international line between Paris and Brussels has also recently been adapted for telegraph work. Total length of lines in France on the Van Rysselberghe system 4,045 kilometres. There are also about 420 kilometres of inter-urban telephone wires independent of the telegraph. In Germany the following lines are in operation:—Berlin - Halle, Berlin - Stettin, Berlin - Dessau, Berlin - Oranienbourg, Breslau-Beuthen, Munich-Augsburg, Nurenberg - Bainberg, Stuttgard - Heilbron, Stuttgard - Broeblingen, Stuttgard - Ulm, Stuttgard - Friedrichshafer—total length of wire 2,512 kilometres. In Austria there is only one line, that between Vienna and Brunn, length 288 kilometres. In Switzerland there are six lines of this character—Geneva-Lausanne (three wires by different routes), Lausanne-Vevey, Zürich - Mannendorf, Bale - Zürich—total length 536 kilometres. In Holland, besides the original Amsterdam-Haarlem line, there are now two others from the Hague to neighbouring villages. There is also a line of 55 kilometres between two towns in the Dutch Indies, Weltevreden and Buitenzorg (Java). In Spain there are lines between Madrid, Burgos, Valencia, and Granada. In Portugal there is a line from Lisbon to Oporto, and thence to Cintra; and in Denmark a line will shortly be opened between Rudkjobing and Vanmenas. This completes the list of European lines on the Van Rysselberghe system, which are either already in use or will be opened very shortly. In addition to these, several important lines are projected in Germany, Austria, Spain, Portugal, Italy, Roumania, Russia, Turkey, and Greece, but the work on these has not yet commenced. The following tables summarise the above statements:—

	Kilometres.
Germany	2,512
Austria	288
Belgium	7,206
Denmark	10
Spain	140
France	4,044
Holland and Colonies	386
Switzerland	536
Total	15,122

The total length of the lines projected amounts to 5,050 kilometres. The system is also in use to a certain extent in the United States, in the Argentine Republic, in Uruguay, in Brazil, in Venezuela, in Mexico, in China and Japan; in fact, it extends more or less over the whole civilised world, with the glaring exception of England and the British Colonies. We have frequently expressed our own estimate of the value of the system, which is, in brief, that wherever telegraphy is intended to play second fiddle then Van Rysselberghe's system is of great value. If, as in the Paris-Brussels case, we have a line built expressly with regard to the telephone service, there can be no difficulty in working off a moderate amount of telegraphy in addition. But the converse does not hold good, and hence the system is not adapted to the majority of English lines. These is no reason, however, why the system should not prove useful in some of our country districts and in many of the Colonies.

The article from which we have prepared the above abstract would have been more useful if it had distinguished in all cases between lines especially built for the double service and old telegraph lines to which the system had been *successfully* applied. We doubt whether the latter class is a very extensive one.

RADIATION FROM DULL AND BRIGHT SURFACES.*

BY J. T. BOTTOMLEY, M.A., F.R.S.E.

In connection with an investigation on heat radiation which I have been carrying on for some time past, and on which I recently presented a communication to the Royal Society, I have had occasion to examine the important results obtained by Mr. Mortimer Evans on the radiation of light and heat from bright and dull surfaces when incandescent (Roy. Soc. *Proc.*, Vol. XL., 1886, p. 207); and I have repeated and verified some of his experiments. Mr. Evans experimented on carbon filaments of incandescent lamps; and in calculating, for my own use, the resistances of the filaments at different degrees of incandescence I was led to an unexpected result, and hence to an investigation of which I desire just now to offer a preliminary notice.

In order to explain, it is necessary for me to state briefly the object and nature of Mr. Evans's experiments. Their object was the comparison of the radiation from surfaces having a bright, polished appearance with that from dull surfaces having the appearance of lampblack; and he was led to an important practical conclusion as to the superior light-giving efficiency of the brilliant-looking filament. For these comparisons the *same* filament was treated in such ways as to alter the surface from dull to bright and back again. It was taken out of the glass globe for the purpose, and after treatment placed in a fresh globe, which was then exhausted. The lamps thus constructed and reconstructed were tested at various candle-powers, the energy for each candle-power being determined.

The tables given in Mr. Evans's paper show for the filaments in different conditions the potential and the current required to maintain different candle-powers from four candles upward. Using his numbers, and supposing Ohm's† law to hold for the carbon filaments, I have calculated the resistances of the filaments at different candle-powers.

Two filaments used by Mr. Evans afforded satisfactory data for my calculations. They are designated in his paper D, DD, DDD, and C, CC, CCC. They had been treated in the following manner:—The filaments D and C were "flashed" so as to have a dull surface with the appearance of lampblack. DD and CC are the same filaments flashed so as to have a brilliant surface, which, though black, has something of the appearance of frosted silver. DDD, CCC, are the same filaments again rendered dull as at first. The following table shows the volts, amperes, and calculated resistances at the candle-powers given in the left-hand column:—

TABLE I.—*Carbon D.*

	D.			DD.			DDD.		
Candles.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.
4	46·5	1·02	45·6	37·3	1·	37·3	34	1·28	26·6
10	52·5	1·20	43·8	42·	1·13	37·17	38·5	1·52	25·3
20	58·3	1·40	41·6	47·8	1·32	36·29	43	1·77	24·3
40	65	1·62	40·1	52·5	1·53	34·3	48	2·06	23·3
50	68	1·70	40·0	54·2	1·60	33·9	50	2·12	23·6*

TABLE II.—*Carbon C.*

	C.			CC.			CCC.		
Candles.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.
4	45	0·86	52·33	34	0·95	35·79	39	1·16	33·62
10	56	1·12	49·99	39	1·12	34·82	44·5	1·38	32·24
20	62	1·28	48·43	44	1·28	34·37	49·5	1·53	32·37*

* The two results which appear last in these tables seem anomalous, and therefore I have not used them in my calculation.

Now, if we suppose the resistance of the carbon filament to depend on the temperature, the resistance diminishing as the temperature increases (though very probably not in simple proportion); and if (as we should do in the case of a metallic wire) we use these resistances in order to compare the temperatures of the filaments at different candle-powers, we are led to a remarkable result. Taking the filament D, and dividing the resistances of D, DD, and DDD at four candles by those at the higher candle-powers, we obtain numbers which may be looked on as ratios of conductances, and which may be taken as indicating, though not exactly representing, corresponding changes in the temperature of the carbon.

* Paper communicated to the Royal Society by Sir W. Thomson, F.R.S.

†I have already commenced an investigation into the question of the conformity of carbon filaments of different temperatures with Ohm's law.

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TABLE III.

To pass from—						D.	DD.	DDD.
4 candles	to	10 candles	increase of conductance is	from 1 to		1·041	1·006	1·047
4	,,	20	,,	,,		1·096	1·028	1·095
4	,,	40	,,	,,		1·137	1·087	1·137
4	,,	50	,,	,,		1·14	1·100	—

The filament C gives confirmatory results, but unfortunately it seems to have broken down early in the condition CCC. I find, however—

TABLE IV.

To pass from—						C.	CC.	CCC.
4 candles	to	10 candles	increase of conductance is	from 1 to		1·047	1·028	1·043
4	,,	20	,,	,,		1·081	1·041	—

Comparing these numbers we are led to the result that, if we admit the assumptions I have made, the temperature to which the carbon must be raised in order that it may give out light of a definite candle-power is higher when the surface is in the dull condition than when it is in a brilliant metallic-looking state.

This result was to me so unexpected that I proceeded to test it directly by the following experiments :—Two glass tubes, similar in every respect, were constructed, containing two precisely similar platinum wires cut from the same hank, which had been specially drawn for me some months before by Messrs. Matthey and Johnson. One of the wires was in its natural bright condition, while the other was covered with the thinnest possible coating of lampblack, which was put on by passing the wire quickly and steadily through the flame of a paraffin lamp. The construction of these tubes is shown in Fig. 1. The platinum wire *a b* is kept stretched by two spiral springs of copper, being silver-soldered to two extremities of these springs. Two loops *l* at the other extremities of the spirals pass over two pieces of glass rod *g g*, *g g*, which are passed in by side tubes, blown on the main glass tube ; and the spirals pull on the glass rods. The ends of the side tubes are sealed up after the glass rods are in their places, with the exception of one, which is used for connecting to the Sprengel pump, and is finally sealed when a complete vacuum has been made. Flexible copper electrodes, *e e*, are silver-soldered to the loops at the ends of the copper springs, and to multiple platinum wires which are sealed into the glass tube at A and B. Fine platinum wires, *p p*, are attached to the main wire, and are brought through the sides of the glass tube ; and these serve as potential testing electrodes. The two tubes and their fittings are, as has been said, perfectly similar in every respect, except that one platinum wire is covered with an extremely thin coating of lampblack.

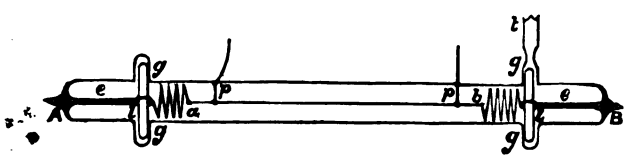

FIG. 1.

The two tubes were attached to a glass fork, and were simultaneously exhausted with the Sprengel pump down to about two millionths of an atmosphere, all the well-understood precautions as to drying, &c., being carefully attended to ; and they were then at the same moment sealed off from the pump. The length of the tubes A B is 22in. over all ; and the internal diameter of the tubes ⅞in. The distance between the potential electrodes *p p* is 15in. (38·1 centimetres). The diameter of the platinum wire *a b* is 0·022in. (0·0599 centimetres). On testing the resistance of the two platinums between the potential electrodes, *cold* and at the same temperature, it was found to be the same for both to less than one one-thousandth part of the resistance of either of them.

The tubes having been prepared as described above, they were connected in parallel arc to a battery of six secondary cells in series, a variable platinoid wire being added in series with the tube containing the bright platinum, in order to regulate its current ; and a rheostat designed for carrying strong currents was used to control the whole. The connections will be readily understood from a glance at Fig. 2.

With the rheostat and the variable platinoid wire the two platinums were then brought to the same incandescence (as judged by the eye) at various brightnesses from just visible redness up to nearly white heat ; and the resistances of the platinums between the potential electrodes were measured by means of a high resistance reflecting galvanometer, suitably arranged, with shunt and interposed resistance, for the purpose in hand.

The result of my experiments is to bear out completely the deduction which I had made from Mr. Mortimer Evans's numbers ; and to show that the temperature which produces, for example, the appearance of a certain red heat, is very much higher when the surface of the heated body is dulled than when it is bright as in a polished metal. I am not yet prepared to give a definite numerical comparison ; but in order to show that the difference of temperatures referred to amounts to many degrees of temperature, I may be allowed to give the following statement :—

The two wires being at the same dull red heat, which from previous experience I estimate at perhaps 600deg. C., in the case of the bright-surfaced wire, the ratio of the resistance of the lampblacked platinum to the bright platinum was 130 : 93. Platinums differ very much as to variation of resistance with temperature ; but in most specimens the resistance is doubled, when the temperature is raised from 0deg. C. to a temperature of from 300deg. C. to 400deg. C., and for any particular platinum wire the change in resistance is almost in simple proportion to the change in temperature. From this statement it may be judged that the difference of temperatures between the two platinums, dull and bright, when giving out the same light, was a great many degrees centigrade.

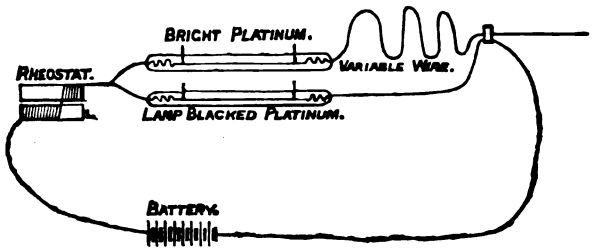

FIG. 2.

The difference of temperatures of the two glass envelopes was also very striking. The glass tube containing the bright wire was not even unpleasantly warm ; while in the case of the other it was so hot as to blister the skin of the hand, and in this connection it is to be remembered that the vacuum in the two tubes was the same.

I propose as soon as possible to continue this investigation and render it more complete.

THE SUPPOSED "NEW FORCE."

BY R. C. SHETTLE, M.D.

(Continued from page 321.)

Experiment 3.—The suspending silk was removed from the supporting rod, and replaced, after giving it half a turn, so as to bring the minor north magnetic pole next to the magnet without any torsion ; the position was again diagonal, and upon completing the circuit the rotation recurred, and finally the minim pole, after similar oscillations, came nearly to rest, as shown in Fig. 6.

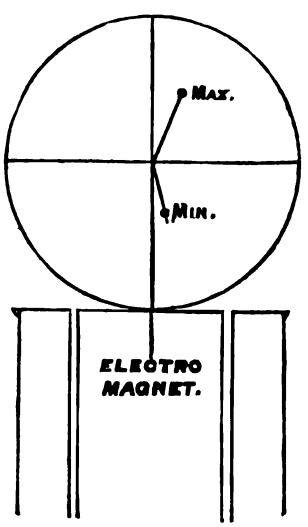

FIG 6.

Experiment 4.—Upon the circuit being broken the spheroid rotated, until the maxim pole came within the hemisphere next the magnet ; on the circuit being completed the rotation was much

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accelerated, and after the usual angular oscillations the spheroid tended to come to rest, as in Fig. 5.

Experiment 5.—The two arms of the electro-magnet were now used, and placed at an angle to each other, so as to permit of the spheroid being placed between them, as in Fig. 7. The battery

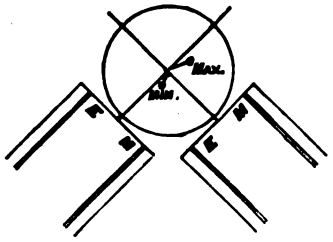

FIG. 7.

current was then turned on, and the spheroid commenced to rotate, the movement passing through the usual angle, and the spheroid tended to come to rest opposite the pole in front of which its maxim pole was situated.

Experiment 6.—The effect of torsion was next shown by rotating the spheroid once upon its axis, and then setting it free, the battery current being maintained, but imparting as little rotary motion as possible. Rotation at once commenced in an endeavour to remove the imparted torsion, but the magnetic force of the maxim pole prevented its passing away from the influence of the magnetic pole in front of which it was placed. This was repeated several times, after which the sphere was rotated once more in the same direction, and again set free, when the same phenomena recurred. The proof of the torsion being considerable in the last case was demonstrated by breaking battery contact, when the spheroid immediately commenced rotating upon its axis in the opposite direction, and the momentum gave it four complete rotations; rotations which were reversed, and reversed again until the sphere was taken down from its position.

Experiment 7.—Two electro-magnets were arranged parallel, one resting on the other, the north and south poles pointing in opposite directions. The spheroid was suspended so that its centre was in a line with the division between the two arms of the electro-magnets, the north pole of the top electro-magnet being directed to the northern hemisphere of the spheroid, and the south pole of the other electro-magnet to the southern hemisphere. Before making battery contact, the poles of the north hemisphere of the spheroid were transverse to the magnetic-field, and the spheroid was at rest without torsion. Upon making battery contact, after an interval of about four seconds, rotation of the spheroid commenced from east to west, in the direction of the hands of a clock; this continued until the poles of the spheroid had arranged themselves in a line with the axis of the electro-magnet; they then oscillated in the opposite direction through about 45deg., stopped, and then again moved from east to west. These oscillations were repeated, but to a diminished extent, when moving from west to east, but always going to the original point in the first direction.

Experiment 8.—When battery current was broken, the spheroid at the time moving from west to east, the oscillations in that direction continued through 180deg. This brought the maxim pole opposite and immediately in front of the north pole of the upper electro-magnet. When in this position, battery contact was re-made, and the maxim pole was brought to rest after a few slight oscillations, in a position on the side of the sphere nearest the electro-magnet.

Experiment 9.—Battery contact was broken, and the direction of the current reversed, so as to convert the pole of the upper electro-magnet nearest the spheroid into a south pole, and the lower electro-magnet into a north pole. The spheroid when at rest now, as in Experiment No. 1, hung without torsion, with its poles transverse to the plane of the electro-magnets. Contact being made, *the same motions of the spheroid were repeated as when the E.M. poles were of opposite signs.* Battery contact was broken, and the maxim pole of the spheroid was allowed to swing back by torsion from west to east.

Experiment 10.—When about 20 deg. beyond the axis of the E.M. poles battery contact was remade, and the maxim pole, after two or three slight oscillations, came to rest on the axis of the electro-magnet poles, and nearest to them; thus showing indifference to their sign.

Experiment 11.—The spheroid was now lowered so that a plane passing horizontally through the two north poles might be in a line with the axis of the lower electro-magnet, which, owing to the direction of the current, was a north pole.

When thus suspended and at rest, without torsion, the poles being transverse to the axis of the electro-magnet, battery contact was made, and axial rotation was established sufficient to bring the maxim pole of the spheroid round to the axis of the magnet.

Experiment 12.—When the current was reversed so as to convert the north pole of the electro-magnet into a south pole, the motion was precisely the same in direction and amount.

Experiment 13.—The spheroid was now raised so that a plane passing horizontally through its south poles was brought level with the axis of the upper limb of the electro-magnet. The spheroid was first subjected to the action of the north and then of the south pole of this limb, and it was found that either pole of the spheroid, when brought under the influence of the arm, was attracted, and after a few oscillations was held.

These experiments were repeated many times and modified, but always with the same results.

Remarks.—The foregoing experiments prove (1) that when insulated copper wire has been cut into lengths and wound in right and left hand helical directions, so that the terminals converge to four centres on opposite sides of a spheroidal mass, such a mass, when suspended before a single pole of an electro-magnet, is converted into a peculiar form of magnet, which manifests polarity at each of the centres to which the terminals of the strands of wire have been drawn.

(2) That the polar phenomena continue so long as the battery current circulates in the electro-magnet.*

(3) That axial rotation of such a spheroid through a certain arc of a circle, by each pole, is established.

(4) Indifference to the sign of the pole of the electro-magnet, is as the pole of the spheroid which is nearest to the magnet attracted.

(5) That time is an essential element in the production of the phenomena, as is shown by an interval elapsing between making battery contact and the motion of the spheroid.

(6) The identity of magnetic and mechanical force, for as the strands of wire run in helical directions round the spheroid, each strand represents a lever by which motion is effected.

SPHEROID No. 2.

A second spheroid was constructed, commencing with a spheroid of willow wood $\frac{3}{4}$in. in diameter. Into the equatorial line, and the sites of the various magnetic poles, pins were driven, as in No. 1. 322ft. of No. ·0075 silk-covered German silver wire were laid on, as already described with the first spheroid.

Experiment 14.—Thus prepared, the spheroid was suspended by a single filament of cocoon silk in front of one of the poles of the electro-magnet. Upon making battery contact axial rotation occurred just as described with spheroid No. 1, either pole being attracted as it happened to be most in proximity to the electro-magnet; but the rotations were quicker and shorter when the pole representing the maxim terrestrial pole held such position.

Experiment 15.—It was considered desirable to test the magnetic character of the india rubber insulite. For this purpose a spheroid was made of the substance, and suspended in front of the electro-magnet by a single filament of cocoon silk. Upon making battery contact no perceptible motion, attraction, repulsion, or axial rotation could be detected.

SPHEROID No. 3.

The surface of a willow wood sphere 1in. in diameter was divided by an equatorial line. Fifty-two pins were driven into this equatorial line, and one about $\frac{1}{4}$ of an inch on either side of a pole which had been pierced from pole to pole through the centre of each hemisphere. Thus prepared, the sphere was covered with silk-covered copper wire, laid on between the pins as in spheroids Nos. 1 and 2, except that in spheroid No. 3 only one layer of wire was laid on. The terminals of the wires of one side of the equatorial line were drawn in a left hand helical direction *to one geographical pole;* the terminals on the other side were taken with a right hand helical twist *to the other pole.* The wires on this spheroid were tied into position by means of thread without insulite.

Experiment 16.—The spheroid was suspended by a single fibre of cocoon silk, and then subjected to the influence of a single pole of the electro-magnet. No motion was perceptible.

The wires were next unwound; one half—*i.e.*, 26, were drawn to one of the pins on one side of the pole, the other 26 to the other pin in the same hemisphere; the terminals of the strands in the other hemisphere were taken to the other two pins, the right and left hand helical direction being again imparted. The wires were tied into position by means of thread.

Experiment 17.—The spheroid, prepared as described, was suspended and subjected to the influence of the magnetic pole, just as it was prior to the re-winding. Axial rotations were set up, as in the case of Nos. 1 and 2.

(To be continued.)

* There appears to be only one mode of explaining these phenomena, viz., by currents being induced in the copper wire of the spheroid by the magnet. If this be so, then such currents are not *momentary* at the time of making and breaking battery contact, but *permanent.*

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THE BRITISH ASSOCIATION MEETING AT MANCHESTER, 1887.

THE PRESIDENT'S ADDRESS.

The following is the Presidential Address of Sir HENRY E. ROSCOE, M.P., D.C.L., LL.D., PH.D., F.R.S., V.P.C.S, delivered to the members of the British Association at Manchester on Wednesday last:—

Manchester, distinguished as the birthplace of two of the greatest discoveries of modern science, heartily welcomes to-day for the third time the members and friends of the British Association for the Advancement of Science. On the occasion of our first meeting in this city in the year 1842, the President, Lord Francis Egerton, commenced his address with a touching allusion to the veteran of science, John Dalton, the great chemist, the discoverer of the laws of chemical combination, the framer of the atomic theory upon which the modern science of chemistry may truly be said to be based. Lord Francis Egerton said: "Manchester is still the residence of one whose name is uttered with respect wherever science is cultivated, who is here to-night to enjoy the honours due to a long career of persevering devotion to knowledge, and to receive from myself, if he will condescend to do so, the expression of my own deep personal regret that increase of years, which to him up to this hour has been but increase of wisdom, should have rendered him in respect of mere bodily strength unable to fill on this occasion an office which in his case would have received more honour than it could confer. I do regret that any cause should have prevented the present meeting in his native town from being associated with the name"—and here I must ask you to allow me to exchange the name of Dalton in 1842 for that of Joule in 1887, and to add again in the words of the President of the former year that I would gladly have served as a doorkeeper in any house where Joule, the father of science in Manchester, was enjoying his just pre-eminence. For it is indeed true that the mantle of John Dalton has fallen on the shoulders of one well worthy to wear it, one to whom science owes a debt of gratitude not less than that which it willingly pays to the memory of the originator of the atomic theory. James Prescott Joule it was who, in his determination of the mechanical equivalent of heat, about the very year of our first Manchester meeting, gave to the world of science the results of experiments which placed beyond reach of doubt or cavil the greatest and most far-reaching scientific principle of modern times, namely, that of the conservation of energy. This, to use the words of Tyndall, is indeed a generalisation of conspicuous grandeur fit to take rank with the principle of gravitation, more momentous, if that be possible, combining as it does the energies of the material universe into an organic whole, and enabling the eye of science to follow the flying shuttles of the universal power as it weaves what the Erdgeist in "Faust" calls "the living garment of God."

It is well, therefore, for us to remember, in the midst of the turmoil of our active industrial and commercial life, that Manchester not only well represents the energy of England in these practical directions, but that it possesses even higher claims to our regard and respect as being the seat of discoveries of which the value not only to pure science is momentous, but which also lie at the foundation of all our material progress and all our industrial success. For without a knowledge of the laws of chemical combination all the marvellous results with which modern industrial chemistry has astonished the world could not have been achieved, whilst the knowledge of the quantitative relations existing between the several forms of energy, and the possibility of expressing their amount in terms of ordinary mechanics, are matters which now constitute the life breath of every branch of applied science. For example, before Dalton's discovery every manufacturer of oil of vitriol—a substance now made each week in thousands of tons within a few miles of this spot—every manufacturer had his own notions of the quantity of sulphur which he ought to burn in order to make a certain weight of sulphuric acid, but he had no idea that only a given weight of sulphur can unite with a certain quantity of oxygen and of water to form the acid, and that an excess of any one of the component parts was not only useless but harmful. Thus, and in tens of thousands of other instances, Dalton replaced rule of thumb by scientific principle. In like manner the applications of Joule's determination of the mechanical equivalent of heat are even more general; the increase and measurement of the efficiency of our steam engines and the power of our dynamos are only two of the numerous examples which might be adduced of the practical value of Joule's work.

If the place calls up these thoughts, the time of our meeting also awakens memories of no less interest, in the recollection that we this year celebrate the Jubilee of Her Most Gracious Majesty's accession to the throne. It is right that the members of the British Association for the Advancement of Science should do so with heart and voice, for although science requires and demands no royal patronage, we thereby express the feeling which must be uppermost in the hearts of all men of science, the feeling of thankfulness that we have lived in an age which has witnessed an advance in our knowledge of nature, and a consequent improvement in the physical, and let us trust also in the moral and intellectual, well being of the people hitherto unknown; an age with which the name of Victoria will ever be associated.

To give even a sketch of this progress, to trace even in the merest outline the salient points of the general history of science during the fifty momentous years of Her Majesty's reign, is a task far beyond my limited powers. It must suffice for me to point out to you, to the best of my ability, some few of the steps of that progress as evidenced in the one branch of science with which I am most familiar, and with which I am more closely concerned—the science of chemistry.

In the year 1837 chemistry was a very different science from that existing at the present moment. Priestley, it is true, had discovered oxygen, Lavoisier had placed the phenomena of combustion on their true basis, Davy had decomposed the alkalis, Faraday had liquefied many of the gases, Dalton had enunciated the laws of chemical combination by weight, and Gay Lussac had pointed out the fact that a simple volumetric relation governs the combination of the gases. But we then possessed no knowledge of chemical dynamics, we were then altogether unable to explain the meaning of the heat given off in the act of chemical combination. The atomic theory was, indeed, accepted, but we were as ignorant of the mode of action of the atoms and as incapable of explaining their mutual relationship as were the ancient Greek philosophers. Fifty years ago, too, the connection existing between the laws of life, vegetable and animal, and the phenomena of inorganic chemistry, was ill understood. The idea that the functions of living beings are controlled by the same forces, chemical and physical, which regulate the changes occurring in the inanimate world, was then one held by only a very few of the foremost thinkers of the time. Vital force was a term in everyone's mouth, an expression useful, as Goethe says, to disguise our ignorance, for

Wo die Begriffe fehlen,
Da tritt ein Wort zur rechten Zeit sich ein.

Indeed, the pioneer of the chemistry of life, Liebig himself, cannot quite shake himself free from the bonds of orthodox opinion, and he who first placed the phenomena of life on a true basis cannot trust his chemical principles to conduct the affairs of the body, but makes an appeal to vital force to help him out of his difficulties; as when in the body politic an unruly mob requires the presence and action of physical force to restrain it and to bring its members under the saving influence of law and order, so, too, according to Liebig's views, in the body corporeal a continued conflict between the chemical forces and the vital power occurs throughout life, in which the latter, when it prevails, ensures health and a continuance of life, but of which defeat insures disease or death. The picture presented to the student of to-day is a very different one. We now believe that no such conflict is possible, but that life is governed by chemical and physical forces, even though we cannot in every case explain its phenomena in terms of these forces; that whether these tend to continue or to end existence depends upon their nature and amount, and that disease and death are as much a consequence of the operation of chemical and physical laws as are health and life.

Looking back again to our point of departure fifty years ago, let us for a moment glance at Dalton's labours, and compare his views and those of his contemporaries with the ideas which now prevail. In the first place it is well to remember that the keystone of his atomic theory lies not so much in the idea of the existence and the indivisible nature of the particles of matter—though this idea was so firmly implanted in his mind that, being questioned on one occasion on the subject, he said to his friend the late Mr. Ransome, "Thou knowst it must be so, for no man can split an atom"—as in the assumption that the weights in these particles are different. Thus whilst each of the ultimate particles of oxygen has the same weight as every other particle of oxygen, and each atom of hydrogen, for example, has the same weight as every other particle of hydrogen, the oxygen atom is sixteen times heavier than that of hydrogen, and so on for the atoms of every chemical element, each having its own special weight. It was this discovery of Dalton, together with the further one that the elements combine in the proportions indicated by the relative weights of their atoms or in multiples of these proportions, which at once changed chemistry from a qualitative to a quantitative science, making the old invocation prophetic, "God created all things according to measure and to weight"

The researches of chemists and physicists during the last fifty years have not only strengthened but broadened the foundations of the great Manchester philosopher's discoveries. It is true that his original numbers, obtained by crude and inaccurate methods, have been replaced by more exact figures, but his laws of combination and his atomic explanation of those laws stand as the great bulwarks of our science.

On the present occasion it is interesting to remember that within a stone's-throw of this place is the small room belonging to our Literary and Philosophical Society which served Dalton as his laboratory. Here, with the simplest of all possible apparatus—a few cups, penny ink bottles, rough balances, and self-made thermometers and barometers—Dalton accomplished his great results. Here he patiently worked, marshalling facts to support his great theory, for as an explanation of his laborious experimental investigations the wise old man says:—"Having been in my progress so often misled by taking for granted the results of others, I have determined to write as little as possible but what I can attest by my own experience." Nor ought we when here assembled to forget that the last three of Dalton's experimental essays—one of which, on a new method of measuring water of crystallisation, contained more than the germ of a great discovery—were communicated to our Chemical Section in 1842, and that this was the last memorable act of his scientific life. In this last of his contributions to science, as in his first, his method of procedure was that which has been marked out as the most fruitful by almost all the great searchers after nature's secrets, namely, the assumption of a certain view as a working hypothesis, and the subsequent institution of experiment to bring this hypothesis to a test of reality upon which a legitimate theory is afterwards to be based. "Dalton," as Henry well says, "valued detailed facts mainly, if not solely, as the stepping stones to comprehensive generalisations."

Next let us ask what light the research of the last fifty years has thrown on the subject of the Daltonian atoms, first, as regards their size; secondly, in respect to their indivisibility and mutual relationships; and thirdly, as regards their motions. As regards the size and shape of the atoms Dalton offered no opinion, for he had no experimental grounds on which to form it, believing that they were inconceivably small and altogether beyond the grasp of our senses aided by the most powerful appliances of art. He was in the habit of representing his atoms and their combinations diagrammatically as round discs or spheres made of

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wood, by means of which he was fond of illustrating his theory. But such mechanical illustrations are not without their danger, for I well remember the answer given by a pupil to a question on the atomic theory: "Atoms are round balls of wood invented by Dr. Dalton." So determinedly, indeed, did he adhere to his mechanical method of representing the chemical atoms and their combinations that he could not be prevailed upon to adopt the system of chemical formulæ introduced by Berzelius and now universally employed. In a letter addressed to Graham in April, 1837, he writes: "Berzelius' symbols are horrifying. A young student in chemistry might as soon learn Hebrew as make himself acquainted with them." And again: "They appear to me equally to perplex the adepts in science, to discourage the learner, as well as to cloud the beauty and simplicity of the atomic theory." But modern research has accomplished, as regards the size of the atom, at any rate to a certain extent, what Dalton regarded as impossible. Thus in 1865 Loschmidt, of Vienna, by a train of reasoning which I cannot now stop to explain, came to the conclusion that the diameter of an atom of oxygen or nitrogen was $\frac{1}{10,000,000}$ of a centimetre. With the highest known magnifying power we can distinguish the $\frac{1}{40,000}$ part of a centimetre; if now we imagine a cubic box each of whose sides has the above length, such a box when filled with air will contain from 60 to 100 millions of atoms of oxygen and nitrogen. A few years later William Thomson extended the methods of atomic measurement, and came to the conclusion that the distance between the centres of contiguous molecule is less than $\frac{1}{5,000,000}$ and greater than $\frac{1}{1,000,000,000}$ of a centimetre; or, to put it in language more suited to the ordinary mind, Thomson asks us to imagine a drop of water magnified up to the size of the earth, and then tells us that the coarseness of the graining of such a mass would be something between a heap of small shot and a heap of cricket balls. Or again, to take Clifford's illustration, you know that our best microscopes magnify from 6,000 to 8,000 times; a microscope which would magnify that result as much again would show the molecular structure of water. Or again, to put it in another form, if we suppose that the minutest organism we can now see were provided with equally powerful microscopes, these beings would be able to see the atoms.

Next, as to the indivisibility of the atom, involving also the question as to the relationships between the atomic weights and properties of the several elementary bodies. Taking Dalton's aphorism, "Thou knowst no man can split an atom," as expressing the view of the enunciator of the atomic theory, let us see how far this idea is borne out by subsequent work. In the first place, Thomas Thomson, the first exponent of Dalton's generalisation, was torn by conflicting beliefs until he found peace in the hypothesis of Prout, that the atomic weights of all the so-called elements are multiples of a common unit, which doctrine he sought to establish, as Thorpe remarks, by some of the very worst quantitative determinations to be found in chemical literature, though here I may add that they were not so incorrect as Dalton's original numbers. Coming down to a somewhat later date, Graham, whose life was devoted to finding what the motion of an atom was, freed himself from the bondage of the Daltonian aphorism, and defined the atom not as a thing which cannot be divided, but as one which has not been divided. With him, as with Lucretius, as Angus Smith remarks, the original atom may be far down. But speculative ideas respecting the constitution of matter have been the scientific relaxation of many minds from olden time to the present. In the mind of the early Greek the action of the atom as one substance taking various forms by unlimited combinations was sufficient to account for all the phenomena of the world. And Dalton himself, though upholding the indivisibility of his ultimate particles, says: "We do not know that any of the bodies denominated elementary are absolutely indecomposable." Again, Boyle, treating of the origin of form and quality, says: "There is one universal matter common to all bodies—an extended divisible and impenetrable substance." Then Graham in another place expresses a similar thought when he writes: "It is conceivable that the various kinds of matter now recognised as different elementary substances may possess one and the same ultimate or atomic molecules existing in different conditions of movement. The essential unity of matter is an hypothesis in harmony with the equal action of gravity upon all bodies." What experimental evidence is now before us bearing upon these interesting speculations? In the first place, then, the space of fifty years has completely changed the face of the inquiry. Not only has the number of distinct well-established elementary bodies increased from fifty-three in 1837 to seventy in 1887 (not including the *twenty* or more new elements recently said to have been discovered by Krüss and Nilson in certain rare Scandinavian minerals), but the properties of these elements have been studied, and are now known to us with a degree of precision then undreamt of. So that relationships existing between these bodies which fifty years ago were undiscernable are now clearly manifest, and it is to these relationships that I would for a moment ask your attention. I have already stated that Dalton measured the relative weights of the ultimate particles by assuming hydrogen as the unit, and that Prout believed that on this basis the atomic weight of all the other elements would be found to be multiples of the atomic weights of hydrogen, thus indicating that an intimate constitutional relation exists between hydrogen and all the other elements.

Since the days of Dalton and Prout the truth or otherwise of Prout's law has been keenly contested by the most eminent chemists of all countries. The inquiry is a purely experimental one, and only those who have a special knowledge of the difficulties which surround such inquiries can form an idea of the amount of labour and self-sacrifice borne by such men as Dumas, Stas, and Marignac in carrying out delicate researches on the atomic weights of the elements. What is, then, the result of these most laborious experiments? It is that, whilst the atomic weights of the elements are not exactly either multiples of the unit or of half the unit, many of the numbers expressing most accurately the weight of the atom approximate so closely to a multiple of that of hydrogen that we are constrained to admit that these approximations cannot be a mere matter of chance, but that some reason must exist for them. What that reason is, and why a close approximation and yet something short of absolute identity exists, is as yet hidden behind the veil; but who is there that doubts that when this association celebrates its centenary this veil will have been lifted, and this occult but fundamental question of atomic philosophy shall have been brought into the clear light of day?

But these are by no means all the relationships which modern science has discovered with respect to the atoms of our chemical elements. So long ago as 1829 Döbereiner pointed out that certain groups of elements exist, presenting in all their properties strongly marked family characteristics, and this was afterwards extended and insisted upon by Dumas. We find, for example, in the well-known group of chlorine, bromine, and iodine, these resemblances well developed, accompanied, moreover, by a proportional graduation in their chemical and physical properties. Thus, to take the most important of all their characters, the atomic weight of the middle term is the mean of the atomic weights of the two extremes. But these groups of triads appeared to be unconnected in any way with one another, nor did they seem to bear any relation to the far larger number of the elements not exhibiting these peculiarities. Things remained in this condition until 1863, when Newlands threw fresh light upon the subject, showing a far-reaching series of relationships. For the first time we thus obtained a glance into the mode in which the elements are connected together, but, like so many new discoveries, this did not meet with the recognition which we now see it deserves. But whilst England thus had the honour of first opening up this new path, it is to Germany and to Russia that we must look for the consummation of the idea. Germany, in the person of Lothar Meyer, keeps, as it is wont to do, strictly within the limits of known facts. Russia, in the person of Mendelejeff, being of a somewhat more imaginative nature, not only seizes the facts which are proved, but ventures on prophecy. These chemists, amongst whom Carnelley must be named, agree in placing all the elementary bodies in a certain regular sequence, thus bringing to light a periodic recurrence of analogous chemical and physical properties, on account of which the arrangement is termed the periodic system of the elements.

In order to endeavour to render this somewhat complicated matter clear to you, I may perhaps be allowed to employ a simile. Let us, if you please, imagine a series of human families, a French one, represented by Dumas; an English one, by name Newlands; a German one, the family of Lothar Meyer; and lastly a Russian one, that of Mendelejeff. Let us next imagine the names of these chemists placed in a horizontal line in the order I have mentioned. Then let us write under each the name of his father, and again, in the next lower line, that of his grandfather, followed by that of his great-grandfather, and so on. Let us next write against each of these names the number of years which has elapsed since the birth of the individual. We shall then find that these numbers regularly increase by a definite amount, *i.e.*, by the average age of a generation, which will be approximately the same in all the four families. Comparing the ages of the chemists themselves we shall observe certain differences, but these are small in comparison with the period which has elapsed since the birth of any of their ancestors. Now, each individual in this series of family trees represents a chemical element; and just as each family is distinguished by certain idiosyncrasies, so each group of the elementary bodies thus arranged shows distinct signs of consanguinity. But more than this, it not unfrequently happens that the history and peculiarities of some member of a family may have been lost, even if the memory of a more remote and more famous ancestor may be preserved, although it is clear that such an individual must have had an existence. In such a case Francis Galton would not hesitate from the characteristics of the other members to reproduce the physical and even the mental peculiarities of the missing member, and should genealogical research bring to light the true personal appearance and mental qualities of the man, these will be found to coincide with Galton's estimate.

Such predictions and such verifications have been made in the case of no less than three of our chemical elements. Thus, Mendelejeff pointed out that if, in the future, certain lacunæ in his table were to be filled, they must be filled by elements possessing chemical and physical properties which he accurately specified. Since that time these gaps have actually been stopped by the discovery of Gallium by Lecoq de Boisbaudron, of Scandium by Nilson, and of Germanium by Winkler, and their properties, both physical and chemical, as determined by their discoverers, agree absolutely with those predicted by the Russian chemist. Nay, more than this, we not unfrequently have had to deal with chemical foundlings, elements whose parentage is quite unknown to us. A careful examination of the personality of such waifs has enabled us to restore them to the family from which they have been separated by an unkind fate, and to give them that position in chemical society to which they are entitled. These remarkable results, though they by no means furnish a proof of the supposition already referred to, viz., that the elements are derived from a common source, clearly point in this direction, and lend some degree of colour to the speculations of those whose scientific imagination, wearying of dry facts, revels in picturing to itself an elemental Bathybius, and in applying to the inanimate, laws of evolution similar to those which rule the animate world. Nor is there wanting other evidence regarding this inquiry, for here heat, the great analyser, is brought into court. The main portion of the evidence consists in the fact that distinct chemical individuals capable of existence at low temperatures are incapable of existence at high ones, but split up into new materials possessing a less complicated structure than the original. And here it may be well to emphasise the distinction which the chemist draws between the atom and the molecule, the latter being a more or less complicated aggregation of atoms, and especially to point out the fundamental difference between the

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question of separating the atoms in the molecule and that of splitting up the atom itself. The decompositions above referred to are, in fact, not confined to compound bodies, for Victor Meyer has proved in the case of iodine that the molecule at high temperatures is broken to atoms, and J. J. Thomson has added to our knowledge by showing that this breaking up of the molecule may be effected not only by heat vibrations, but likewise by the electrical discharge at a comparatively low temperature.

How, far, now, has this process of simplification been carried? Have the atoms of our present elements been made to yield? To this a negative answer must undoubtedly be given, for even the highest of terrestrial temperatures, that of the electric spark, has failed to shake any one of these atoms in two. That this is the case has been shown by the results with which spectrum analysis, that new and fascinating branch of science, has enriched our knowledge, for that spectrum analysis does give us most valuable aid in determining the varying molecular conditions of matter is admitted by all. Let us see how this bears on the question of the decomposition of the elements, and let us suppose for a moment that certain of our present elements, instead of being distinct substances, were made up of common ingredients, and that these compound elements, if I may be allowed to use so incongruous a term, are split up at the temperature of the electric spark into less complicated molecules. Then the spectroscopic examination of such a body must indicate the existence of these common ingredients by the appearance in the spark spectra of these elements of identical bright lines. Coincidences of this kind have indeed been observed, but on careful examination these have been shown to be due either to the presence of some one of the other elements as an impurity or to insufficient observational power. This absence of coincident lines admits, however, of two explanations—either that the elements are not decomposed at the temperature of the electric spark, or, what appears to me a much more improbable supposition, each one of the numbers of bright lines exhibited by every element indicates the existence of a separate constituent, no two of this enormous number being identical.

Terrestrial analysis having thus failed to furnish favourable evidence, we are compelled to see if any information is forthcoming from the chemistry of the sun and stars. And here I would remark that it is not my purpose now to dilate on the wonders which this branch of modern science has revealed. It is sufficient to remind you that chemists thus have the means placed at their disposal of ascertaining with certainty the presence of elements well known on this earth in fixed stars so far distant that we are now receiving the light which emanated from them perhaps even thousands of years ago.

Since Bunsen and Kirchhoff's original discovery in 1859, the labours of many men of science of all countries have largely increased our knowledge of the chemical constitution of the sun and stars, and to no one does science owe more in this direction than to Lockyer and Huggins in this country, and to Young in the New England beyond the seas. Lockyer has of late years devoted his attention chiefly to the varying nature of the bright lines seen under different conditions of time and place on the solar surface, and from these observations he has drawn the inference that the matching observed by Kirchhoff between, for instance, the iron lines as seen in our laboratories and those visible in the sun, has fallen to the ground. He further explains this want of uniformity by the fact that at the higher transcendental temperatures of the sun the substance which we know here as iron is resolved into separate components. Other experimentalists, however, while accepting Lockyer's facts as to the variations in the solar spectrum, do not admit his conclusions, and would rather explain the phenomena by the well-known differences which occur in the spectra of all the elements when their molecules are subject to change of temperature or change of position.

Further, arguments in favour of this idea of the evolution of the elements have been adduced from the phenomena presented by the spectra of the fixed stars. It is well known that some of these shine with a white, others with a red, and others again with a blue light; and the spectroscope, especially under the hands of Huggins, has shown that the chemical constitution of these stars is different. The white stars, of which Sirius may be taken as a type, exhibit a much less complicated spectrum than the orange and the red stars; the spectra of the latter remind us more of those of the metalloids and of chemical compounds than of the metals. Hence it has been argued that in the white, presumably the hottest, stars a celestial dissociation of our terrestrial elements may have taken place, whilst in the cooler stars, probably the red, combination even may occur. But even in the white stars we have no *direct* evidence that a decomposition of any terrestrial atom has taken place; indeed, we learn that the hydrogen atom, as we know it here, can endure unscathed the inconceivably fierce temperature of stars presumably many times more fervent than our sun, as Sirius and Vega.

Taking all these matters into consideration, we need not be surprised if the earthbound chemist should, in the absence of celestial evidence which is incontestable, continue, for the present at least, and until fresh evidence is forthcoming, to regard the elements as the unalterable foundation stones upon which his science is based.

Pursuing another line of inquiry on this subject, Crookes has added a remarkable contribution to the question of the possibility of decomposing the elements. With his well-known experimental prowess, he has discovered a new and beautiful series of phenomena, and has shown that the phosphorescent lights emitted by certain chemical compounds, especially the rare earths, under an electric discharge in a high vacuum exhibit peculiar and characteristic lines. For the purpose of obtaining his material Crookes started from a substance believed by chemists to be homogeneous, such, for example, as the rare earth yttria, and succeeded by a long series of fractional precipitations in obtaining products which yield different phosphorescent spectra, although when tested by the ordinary methods of what we may term high temperature spectroscopy, they appear to be the one substance employed at the starting point. The other touchstone by which the identity, or otherwise, of these various products might be ascertained, viz., the determination of their atomic weights, has not, as yet, engaged Crookes's attention. In explanation of the singular phenomena the discoverer suggests two possibilities. First, that the bodies yielding the different phosphorescent spectra are different elementary constituents of the substance which we call yttria. Of, if this be objected to because they all yield the same spark spectrum, he adopts the very reasonable view that the Daltonian atom is probably, as we have seen, a system of chemical complexity; and adds to this the idea that these complex atoms are not all of exactly the same constitution and weight, the differences, however, being so slight that their detection has hitherto eluded our most delicate tests, with the exception of this one of phosphorescence in a vacuum. To these two explanations, Marignac, in a discussion of Crookes' results, adds a third. It having been shown by Crookes himself that the presence of the minutest traces of foreign bodies produce remarkable alterations in the phosphorescent spectra, Marignac suggests that in the course of the thousands of separations which must be made before these differences become manifest, traces of foreign bodies may have been accidentally introduced, or, being present in the original material, may have accumulated to a different extent in the various fractions, their presence being indicated by the only test by which they can now be detected. Which of these three explanations is the true one must be left to future experiment to decide.

We must now pass from the statics to the dynamics of chemistry; that is, from the consideration of the atoms at rest to that of the atoms in motion. Here again we are indebted to John Dalton for the first step in this direction, for he showed that the particles of a gas are constantly flying about in all directions; that is, that gases diffuse into one another, as an escape of coal gas from a burner, for example, soon makes itself perceptible throughout the room. Dalton, whose mind was constantly engaged in studying the molecular condition of gases, first showed that a light gas cannot rest upon a heavier gas as oil upon water, but that an interpenetration of each gas by the other takes place. It is, however, to Graham's experiments, made rather more than half a century ago, that we are indebted for the discovery of the law regulating these molecular motions of gases, proving that their relative rates of diffusion are inversely proportional to the square roots of their densities, so that oxygen being sixteen times heavier than hydrogen, their relative rates of diffusion are 1 and 4.

But whilst Dalton and Graham indicated that the atoms are in a continual state of motion, it is to Joule that we owe the first accurate determination of the rate of that motion. At the Swansea meeting in 1848 Joule read a paper before Section A "On the Mechanical Equivalent of Heat, and on the Constitution of Elastic Fluids." In this paper Joule remarks that whether we conceive the particles to be revolving round one another according to the hypothesis of Davy, or flying about in every direction according to Herepath's view, the pressure of the gas will be in proportion to the *vis viva* of its particles. "Thus it may be shown that the particles of hydrogen at the barometrical pressure of 30in. at a temperature of 60deg. must move with a velocity of 6225·54ft. per second in order to produce a pressure of 14·7141bs. on the square inch;" or, to put it in other words, a molecular cannonade or hailstorm of particles, at the above rate—a rate, we must remember, far exceeding that of a cannon ball—is maintained against the bounding surface.

We can, however, go a step further and calculate with Clerk Maxwell the number of times in which this hydrogen molecule, moving at the rate of 70 miles per minute, strikes against others of the vibrating swarm, and we learn that in one second of time it must knock against others no less than 18 thousand million times.

And here we may pause and dwell for a moment on the reflection that in nature there is no such thing as great or small, and that the structure of the smallest particle, invisible even to our most searching vision, may be as complicated as that of any one of the heavenly bodies which circle round our sun.

But how does this wonderful atomic motion affect our chemistry? Can chemical science or chemical phenomena throw light upon this motion, or can this motion explain any of the known phenomena of our science? I have already said that Lavoisier left untouched the dynamics of combustion. He could not explain why a fixed and unalterable amount of heat is in most cases emitted but in some cases absorbed when chemical combination takes place. What Lavoisier left unexplained Joule has made clear. On August 25, 1843, Joule read a short communication, I am glad to remember, before the Chemical Section of our Association, meeting that year at Cork, containing an announcement of a discovery which was to revolutionise modern science. This consisted in the determination of the mechanical equivalent of heat, in proving by accurate experiment that the expenditure of energy equal to that developed by the weight of 772lb. falling through one foot at Manchester, the temperature of one pound of water can be raised 1deg. Fahr. In other words, every change in the arrangement of the particles is accompanied by a definite evolution or an absorption of heat. In all such cases the molecular energy leaves the potential to assume the kinetic form, or *vice versâ*. Heat is evolved by the clashing of the atoms, and this amount is fixed and definite.

Thus it is to Joule we owe the foundation of chemical dynamics and the basis of thermal chemistry. As the conservation of mass or the principle of the indestructibility of matter forms the basis of chemical statics, so the principle of the conservation of energy* constitutes the foundation of chemical dynamics. Change in the form of matter and change in the form of energy are the universal accompaniments of every chemical operation. Here again it is to Joule we owe the proof of the truth of

* "The total energy of any material system is a quantity which can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible."—MAXWELL.

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this principle in another direction, viz., that when electrical energy is developed by chemical change a corresponding quantity of chemical energy disappears. Energy as defined by Maxwell is the power of doing work, and work is the act of producing a change of configuration in a system in opposition to a force which resists that change. Chemical action produces such a change of configuration in the molecules. Hence, as Maxwell says, "a complete knowledge of the mode in which the potential energy of a system varies with the configuration would enable us to predict every possible motion of the system under the action of given external forces, provided we were able to overcome the purely mathematical difficulties of the calculation." The object of thermal chemistry is to measure these changes of energy by thermal methods, and to connect these with chemical changes, to estimate the attractions of the atoms and molecules to which the name of chemical affinity has been applied, and thus to solve the most fundamental problem of chemical science. How far has modern research approached the solution of this most difficult problem? How far can we answer the questions, what is the amount of the forces at work in these chemical changes? What laws govern these forces? Well, even in spite of the results with which recent researches—especially the remarkable ones of the Danish philosopher Thomsen—have enriched us, we must acknowledge that we are yet scarcely in sight of Maxwell's position of successful prediction. Thermal chemistry, we must acknowledge, is even yet in its infancy; it is, however, an infant of sturdy growth, likely to do good work in the world, and to be a credit to him who is its acknowledged father, as well as to those who have so carefully tended it in its early years.

But recent investigation in another direction bids fair even to eclipse the results which have been obtained by the examination of thermal phenomena. And this lies in the region of electrical chemistry. Faraday's work relating to conductivity of chemical substances has been already referred to, and this has been since substantiated and extended to pure substances by Kohlrausch. It has been shown, for example, that the resistance of absolutely pure water is almost an infinite quantity. But a small quantity of an acid, such as acetic or butyric acid, greatly increases the conductivity; but more than this, it is possible by determination of the conductivity of a mixture of water with these two acids to arrive at a conclusion as to the partition of the molecules of the water between the acids. Such a partition, however, implies a change of position, and therefore we are furnished with a means of recognising the motion of the molecules in a liquid, and of determining its amount. Thus it has been found that the hindrance to molecular motion is more affected by the chemical character of the liquid than by physical characters such as viscosity. We have seen that chemical change is always accompanied by molecular motion, and further evidence of the truth of this is gained from the extraordinary chemical inactivity of pure unmixed substances. Thus pure anhydrous hydrochloric acid does not act upon lime, whereas the addition of even a trace of moisture sets up a most active chemical change, and hundreds of other examples of a similar kind might be stated. Bearing in mind that these pure anhydrous compounds do not conduct, we are led to the conclusion that an intimate relation exists between chemical activity and conductivity. And we need not stop here; for a method is indicated, indeed, by which it will be possible to arrive at a measure of chemical affinity from determination of conductivity. It has, indeed, been already shown that the rate of change in the saponification of acetic ether is directly proportional to the conductivity of the liquid employed.

Such wide-reaching inquiries into new and fertile fields, in which we seem to come into nearer touch with the molecular state of matter, and within a measurable distance of accurate mathematical expression, leads to confident hope that Lord Rayleigh's pregnant words at Montreal may ere long be realised:—"It is from the further study of electrolysis that we may expect to gain improved views as to the nature of chemical reactions, and of the forces concerned in bringing them about; and I cannot help thinking that the next great advance, of which we already have some foreshadowing, will come on this side."

There is, perhaps, no branch of our science in which the doctrine of the Daltonian atom plays a more conspicuous part than in organic chemistry or the chemistry of the carbon compounds, as there is certainly none in which such wonderful progress has been made during the past fifty years. One of the most striking and perplexing discoveries made rather more than half a century ago was that chemical compounds could exist which, whilst possessing an identical chemical composition—that is, containing the same percentage quantity of their constituents—are essentially distinct chemical substances exhibiting different properties. Dalton was the first to point out the existence of such substances, and to suggest that the difference was to be ascribed to a different or to a multiple arrangement of the constituent atoms. Faraday soon afterwards proved that this supposition was correct, and the research of Liebig and Wöhler on the identity of composition of the salts of fulminic and cyanic acid gave further confirmation to the conclusion, leading Faraday to remark that "now we are taught to look for bodies composed of the same elements in the same proportion but differing in their qualities, they may probably multiply upon us." How true this prophecy has become we may gather from the fact that we now know of thousands of cases of this kind, and that we are able not only to explain the reason of their difference by virtue of the varying position of the atoms within the molecule, but even to predict the number of distinct variations in which any given chemical compound can possibly exist. How large this number may become may be understood from the fact that, for example, one chemical compound, a hydro-carbon containing thirteen atoms of carbon combined with twenty-eight atoms of hydrogen, can be shown to be capable of existing in no less than 802 distinct forms.

Experiment in every case in which it has been applied has proved the truth of such a prediction, so that the chemist has no need to apply the cogent argument sometimes said to be used by experimentalists enamoured of pet theories, "When facts do not agree with theory, so much the worse for the facts!" This power of successful prediction constitutes a high-water mark in science, for it indicates that the theory upon which such a power is based is a true one. But if the Daltonian atom forms the foundation of this theory, it is upon a knowledge of the mode of arrangement of these atoms and on a recognition of their distinctive properties that the superstructure of modern organic chemistry rests. Certainly it does appear almost to verge on the miraculous that chemists should now be able to ascertain with certainty the relative position of atoms in a molecule so minute that millions upon millions, like the angels in the schoolmen's discussion, can stand on a needle's point. And yet this process of orientation is one which is accomplished every day in our laboratories, and one which more than any other has led to results of a startling character. Still, this sword to open the oyster of science would have been wanting to us if we had not taken a step farther than Dalton did, in the recognition of the distinctive nature of the elemental atoms. We now assume on good grounds that the atom of each element possesses distinct capabilities of combination; some a single capability, others a double, others a triple, and others, again, a fourfold combining capacity. The germs of this theory of valency, one of the most fruitful of modern chemical ideas, were enunciated by Frankland in 1852, but the definite explanation of the linking of atoms, of the tetrad nature of the carbon atoms, their power of combination, and of the difference in structure between the fatty and aromatic series of compounds, was first pointed out by Kekulé in 1857; though we must not forget that this great principle was foreshadowed so long ago as 1833 from a physical point of view by Faraday in his well-known laws of electrolysis, and that it is to Helmholtz in his celebrated Faraday lecture that we owe the complete elucidation of the subject, for, whilst Faraday has shown that the number of the atoms electrolytically deposited is in the inverse ratio of their valencies, Helmholtz has explained this by the fact that the quantity of electricity with which each atom is associated is directly proportional to its valency.

Amongst the tetrad class of elements, carbon, the distinctive element of organic compounds, finds its place; and the remarkable fact that the number of carbon compounds far exceeds that of all the other elements put together receives its explanation. For these carbon atoms not only possess four means of grasping other atoms, but these four-handed carbon atoms have a strong partiality for each other's company, and readily attach themselves hand in hand to form open chains or closed rings to which the atoms of other elements join to grasp the unoccupied carbon hand, and thus to yield a dancing company in which all hands are locked together. Such a group, each individual occupying a given position with reference to the others, constitutes the organic molecule. When, in such a company, the individual members change hands, a new combination is formed. And as in such an assembly the eye can follow the changing positions of the individual members, so the chemist can recognise in his molecule the position of the several atoms, and explain by this the fact that each arrangement constitutes a new chemical compound possessing different properties, and account in this way for the decompositions which each differently constituted molecule is found to undergo. Chemists are, however, not content with representing the arrangement of the atoms in one plane, as on a sheet of paper, but attempt to express the position of the atoms in space. In this way it is possible to explain certain observed differences in isomeric bodies which otherwise baffled our efforts. To Van t'Hoff, in the first instance, and more recently to Wislicenus, chemistry is indebted for work in this direction, which throws light on hitherto obscure phenomena, and points the way to still further and more important advances.

It is this knowledge of the mode in which the atoms in the molecule are arranged, this power of determining the nature of this arrangement, which has given to organic chemistry the impetus which has overcome so many experimental obstacles, and given rise to such unlooked for results. Organic chemistry has now become synthetic. In 1837 we were able to build up but very few and very simple organic compounds from their elements; indeed the views of chemists were much divided as to the possibility of such a thing. Both Gmelin and Berzelius argued that organic compounds, unlike inorganic bodies, cannot be built up from their elements. Organic compounds were generally believed to be special products of the so-called vital force, and it was only intuitive minds, like those of Liebig and Wöhler, who foresaw what was coming, and wrote in 1837 strongly against this view, asserting that the artificial production in our laboratories of all organic substances, so far as they do not constitute a living organism, is not only probable but certain. Indeed, they went a step farther, and predicted that sugar, morphia, salicine, will all thus be prepared; a prophecy which, I need scarcely remind you, has been after fifty years fulfilled, for at the present time we can prepare an artificial sweetening principle, an artificial alkaloid, and salicine.

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS.

In our last issue we gave a list of the subjects of an electrical nature upon which communications are invited by the Council of the Institution of Civil Engineers. For the benefit of those of our readers who may not happen to be acquainted with the conditions under which these papers are received, we subjoin the information which accompanies the list:—

"The Council of the Institution of Civil Engineers invites original communications on the subjects included in the following list, as well as on any other questions of professional interest. For approved papers the council has the power to award premiums, arising out of special funds bequeathed for the purpose, the particulars of which are as under:—

"1. The *Telford Fund*, left in trust, the interest to be expended in

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annual premiums, under the direction of the council.' This bequest (with accumulations of dividends) produces £260 annually.

"The *Manby Donation*, of the value of about £10 a year, given 'to form a fund for an annual premium or premiums for papers read at the meetings.'

"3. The *Miller Fund*, bequeathed by the testator 'for the purpose of forming a fund for providing premiums or prizes for the students of the said institution, upon the principle of the Telford Fund.' This fund (with accumulations of dividends) realises £150 per annum. Out of this fund the council has established a scholarship, called 'The Miller Scholarship of the Institution of Civil Engineers,' and is prepared to award one such scholarship, not exceeding £40 in value, each year, and tenable for three years.

"4. The *Howard Bequest*, directed by the testator to be applied 'for the purpose of presenting periodically a prize or medal to the author of a treatise on any of the uses or properties of iron, or to the inventor of some new and valuable process relating thereto, such author or inventor being a member, graduate, or associate of the said institution.' The annual income amounts to nearly £16. It has been arranged to award this prize every five years, commencing from 1887. The next award will therefore be made in 1892.

"The council will not make any award unless a communication of adequate merit is received, but will give more than one premium if there are several deserving memoirs on the same subject. In the adjudication of the premiums no distinction will be made between essays received from members of the institution or strangers, whether natives or foreigners, except in the cases of the Miller and the Howard bequests, which are limited by the donors.

Instructions for Preparing Communications.

"In writing these essays the use of the first person should be avoided. They should be legibly transcribed on foolscap paper, on one side only, leaving a margin on the left side, in order that the sheets may be bound. Every paper must be prefaced by an abstract of its contents, not exceeding 1,500 words in length.

"Illustrations, when necessary, should be drawn on tracing-paper, to as small a scale as is consistent with distinctness, but in no case should any figure exceed 6½ inches in height. When an illustrated communication is accepted for reading, a series of diagrams will be required sufficiently large and boldly coloured to be clearly visible at a distance of 60ft. These diagrams will be returned.

"Papers which have been read at the meetings of other societies, or have been published, cannot be read at a meeting of the institution, nor be admitted in competition for the premiums.

"The communications must be forwarded to the secretary of the institution, from whom any further information may be obtained. There is no specified date for the delivery of MSS., as when a paper is not in time for one session it is dealt with in the succeeding one."

COMPANIES' MEETINGS.

Lancashire and Cheshire Telephonic Exchange Company.

The sixth annual meeting of this Company was held on Monday last at the Memorial Hall, Manchester, under the presidency of Mr. Charles Moseley, chairman of the Company.

The SECRETARY and GENERAL MANAGER (Mr. Kenneth MacIver) read the notice convening the meeting, and the report of the Directors, which appeared in our last issue, was taken as read.

The CHAIRMAN, in moving the adoption of the report, said it was a source of great satisfaction to the Directors to have gone through another financial year with such very satisfactory results. The revenue showed an increase of nearly £10,000 on the previous year. The income from their trunk wires showed a considerable increase, and the tendency seemed to be growing to use the wires between long distance towns. The mileage of the company had increased during the year from 6,203 to 7,253, and the probability was that the mileage would go on increasing year after year. The number of messages sent over the wires during the year was eleven and a-half millions, being an increase of half a million. The average cost of the message was 1d. The Company were now seeking to extend the radius of their operations. They contemplated making arrangements with the National Company for connection with Staffordshire towns in the same way as arrangements had been made with the same Company for communication with Yorkshire, and before long it was hoped that their connection with the Midland district would be complete. They also hoped to connect with the salt district, and with Chester and with North Wales. Arrangements were being made with a view to the introduction of a new switching apparatus in Manchester, similar to the one which had answered so satisfactorily in Liverpool, and advantage was being taken of this opportunity to concentrate into one switch room all the telephone wires at present dispersed over three separate switch rooms in different parts of the city. A reduction had been made during the year in maintenance charges of £300, and this notwithstanding the great increase in mileage. Against this there was an increase of £4,500 in the general expenses. The Directors could assure the shareholders that this expense had been unavoidable, but there were reasons why it was not desirable to explain the matter further. Their relations with the Post Office continued in the same undesirable condition. Since the commencement of the business the Company had sent the cotton report to their subscribers, and now the Postmaster-General had forbidden this, and under penalty of losing their licence they had to submit.

Mr. HOFFGAARD, in seconding the motion, asked if any move had been made by the Company with a view to get communication with London.

The CHAIRMAN said the matter was a difficult one to deal with. Their own system did not extend beyond Lancashire and Cheshire, so that they could not initiate a demand for communication with London. In this matter they were in the hands of the parent company, and the parent company, he was sorry to say, had not shown itself very enterprising. The opinion of the meeting would be sent to them, and perhaps it would stir them up.

Mr. Alderman Thompson was re-elected a Director of the Company, and after a cordial vote of thanks to the Directors the proceedings terminated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th inst. amounted to £3,870.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended August 26th, amounted to £2,672, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug 31.		Business Done Week Ending Aug. 31. Highest.		Lowest.	
Anglo-American	37½,	38½	..... 37⅞	.....	—	
Do. Preferred	60,	61	 61	.....	59½	
Do. Deferred	14½,	15½	..... 14⅞	.....	14⅛	
Brazilian Submarine	11⅛,	11⅜	..... 11 5-16	.....	11⅛	
Cuba	11¾,	12¼	..... 12¼	.....	12	
Do. Preference	18,	19	..... —	.....	—	
Direct Spanish	2⅜,	3	..... —	.....	—	
Do. Preference	7⅛,	8½	..... —	.....	—	
Direct United States Cable	8⅞,	9⅛	..... 8⅞	.....		xd.
stern elegraph	10⅞,	11¼	..... 11¼	.....	11	
Do. 6 per Cent. Preference	14,	14½	 14	.....	—	
Do. 5 per Cent. Debentures, 1899	106,	109	 107	.....	—	
Eastern Extension	11⅞,	12	 12	.....	11⅞	
German Union	10½,	11	..... —	.....	—	
Globe Telegraph and Trust	5⅜,	5⅝	..... 5⅝	.....	5⅜ xd.	
Do. Preference	13⅛,	13⅜	..... 13 5-16	.....	13 1-16 xd.	
Great Northern	13⅛,	14	.....13 15-16	.....	13⅜	
Indo-European	85,	87	..... —	.....	—	
Reuter's	7⅞,	8	..... —	.....	—	
Submarine	170,	180	 175	.....	—	
West India and Panama	⅝,	¾	..... ⅝	.....	9-16	
Do. 1st Preference	9,	9½	..... 9½	.....	—	
Western Brazilian	7⅞,	8	 8	.....	7⅞	
Western Union 7 per Cent. 1st Mortgage	120,	125	..... —	.....	—	
Do. 6 per Cent. Sterling Bonds	104,	107	..... —	.....	—	

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	..... —	.....	—	
Oriental	5-16	7-16	 5-16	.....	—	
United Telephone	11⅛,	12	..... 11⅜	.....	11⅞	
United River Plate	4½,	5	..... —	.....	—	

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	..... —	.....	—	
Do. (fully paid)	3,	4	..... —	.....	—	
Swan	1½,	1¾	..... —	.....	—	
Maxim Weston	⅛,	¼	..... —	.....	—	

MISCELLANEOUS.

elegraph Construction	36½,	37½	 37	.....	36	
India Rubber, Gutta Percha, and Telegraph Works	22,	23	..... 22¾	.....	22¾	

THE ELECTRIC APPARATUS COMPANY, Limited.

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Depots: 4, Charing Cross, S.W., and 65, Faulkner St., Manchester.
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Electric Light Fittings, Edison-Swan Lamps, Schuckert's Ammeters, Voltmeters and Speedometers.

Specially Low Quotations for Electric Light Cables.

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MEDICAL APPLIANCES.

SHIPPERS AND THE TRADE SPECIALLY STUDIED.

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NOTES.

ELECTRIC LIGHT AT THE HAYMARKET THEATRE.—On the reopening of this theatre in a few days' time it will be lit by electricity.

SALE OF ELECTRIC PLANT.—In our advertising columns notice will be found of a forthcoming sale of the electric lighting plant now in use at the Liverpool Exhibition.

THE SOUTH FORELAND ELECTRIC LIGHTHOUSE.—The *Globe* of yesterday (Thursday) evening contains an interesting article by "An Amateur," describing a night in the South Foreland Electric Lighthouse.

LIGHTING OF COLLIERIES.—Mr. Ellis Lever, writing to *The Times* on the Exeter disaster, mentions that he has just heard of an order being given for 2,000 electric safety lamps for a South Wales colliery.

FINSBURY TECHNICAL COLLEGE.—We would call the attention of our readers to the notice in another column with regard to the winter session of the day and evening classes at the Finsbury Technical College.

TELEPHONE LICENSE ISSUED.—We are informed that the Postmaster-General has granted a license to the Equitable Telephone Association authorising them to establish telephone exchanges in the United Kingdom.

OUR COLUMNS.—The pressure on our columns this week, owing to the British Association, compels us to leave over some interesting papers, including the continuation of our articles on "The Rise and Progress of Telephony in the United Kingdom," as well as some correspondence.

ST. PETERSBURG OIL LIGHTING EXHIBITION.—We are requested to state that the time for receiving applications for the electric light department of the forthcoming exhibition at St. Petersburg has been extended to the 27th September, and that exhibits will be received up to the 27th October.

"ELECTRICAL DISTRIBUTION BY ALTERNATING CURRENTS AND TRANSFORMERS."—We have received from Messrs. Alabaster, Gatehouse and Co. a copy of "Electrical Distribution by Alternating Currents and Transformers," by Mr. Rankin Kennedy, an interesting work which we shall shortly notice at greater length.

THE LIQUIDATION OF THE GÜLCHER COMPANY.—At a meeting of the committee of investigation appointed by the creditors of the Gülcher Company resolutions were adopted recommending that the liquidation be effected under the supervision of the High Court of Justice, and that Mr. W. C. Jackson be appointed as liquidator.

FALMOUTH.—The Royal Cornwall Polytechnic Society is holding an exhibition at Falmouth. Electrical apparatus is shown by Mr. W. H. Perrow, electrician, of Truro, and by the Electric Apparatus Company of London. On Friday Mr. J. M. Carr, of St. Austell, will lecture on the "Production and Transmission of Electric Energy."

THE WESTERN COUNTIES AND SOUTH WALES TELEPHONE SERVICE.—On Monday last the Western Counties and South Wales Telephone Company opened several public call rooms in Bristol and in Gloucester, which will be available for communication over the trunk lines of the system as well as for the local service. The charges for the more distant places amount to 9d. and 1s. for three minutes' conversation.

LIVERPOOL.—At the meeting of the Liverpool City Council on Wednesday, a long discussion took place upon a recommendation of the Health Committee to apply for Parliamentary powers to authorise the use of steam "or other mechanical power," on their tramway. The resolution was eventually carried. The Picton Library, after being lit for some while by electricity, is to revert to gas. Great opposition was raised in the council to this step.

PERSONAL.—Messrs. Muir, Mason and Coulson, the well known electrical engineers, of Glasgow, inform us that they have taken into partnership Mr. J. D. F. Andrews, who lately carried on business under the name of J. D. F. Andrews and Co. The inventions of Mr. Andrews, which have been successfully applied to upwards of forty steamships and numerous land installations, become the property of the firm, which will, however, remain unaltered in style and title.

THE ECLIPSE BATTERY.—A few days ago a number of members of Parliament and others were privileged to examine, in one of the committee rooms of the House, some specimens of the Eclipse primary battery. The lamp used is of 2½ candle-power, and is described as having a semi-metallic filament. The charge is said to last for 12 hours, at a cost of 1d. for renewal of the liquid. The promoters of this battery are evidently well up to their work and are determined to keep the ball rolling as long as possible.

THE LIGHTING OF THE GLASGOW UNDERGROUND RAILWAY.—We hear with regret that the arrangements for lighting the trains in the tunnels of the Glasgow Underground Railway have not been completely successful as carried out by Mr. Carswell. It appears that the rolling contact by which current is taken from the stationary conductor does not work very satisfactorily, and the lights are consequently often below candle-power. If, however, our information is ill-founded we should be glad of a correction.

SUBMARINE COAST DEFENCES.—An intimation has been received at Portsmouth that, in consequence of the decision of a committee which sat to consider the question of coast defences, a series of submarine mines and electric contact wires will be laid in the channels through which large ships of war would approach Spithead, and it is probable that the whole of the forts will be connected with the mainland by a telegraph cable. As regards the latter point it is simply astounding that this should not have been done long before.

DAMAGE CAUSED BY GAS LIGHTING IN THE HOUSES OF PARLIAMENT.—In the House of Commons, on Thursday, Mr. Plunket, in answer to Mr. C. Graham, said there was no doubt that the use of gas in the cloister used as a cloak room was doing a certain amount of damage to the stonework of the roof, and he agreed as to the advisability of substituting the electric light. Unfortunately there was the odious question of expense, and he had been for some time engaged in having estimates prepared, which he hoped soon to submit to the proper authorities.

"PROF. ROGERS, F.R.S."—We learn from some of the daily journals that amongst the papers read before the British Association in Section G were two by Prof. Rogers—one on a new current meter, and one on a system of underground mains. We are sorry to say that the representatives of this journal have been unable to learn anything further of these papers or even of their distinguished author. By some singular coincidence it happens, however, that on the same day Prof. George Forbes, F.R.S., read a couple of papers in the same section on the very same subjects. Prof. Forbes is evidently a very near relation of "Prof. Rogers."

ELECTRICITY OF CONTACT OF GASES WITH LIQUIDS.—Replying in *Nature* to the communication of Mr. Enright (which was quoted in our columns on Aug. 26th, p. 329). Prof. Oliver Lodge writes as follows:—"Will you allow me to ask Mr. Enright how he proved that the 'charge of the escaping hydrogen was positive' or negative, as the case may

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be? That the escaping *spray* was electrified by friction, after the manner of the steam spray in Armstrong's old hydro-electric machine, is a natural explanation of these capricious effects; but that *gas* should be thus electrified, and that this electrification should have any relation whatever to the subject of 'atomic charge,' are propositions which strike one as improbable."

MESSRS. KING, MENDHAM AND CO.'S CATALOGUE.—Messrs. King, Mendham and Co., of Bristol, send us a copy of the latest issue of their price list and catalogue, a profusely illustrated book of some 150 pages. In it are described and illustrated some new forms of the well-known Wimshurst statical machines, of which they are the makers. Automatic gas lighting apparatus, electric alarms, telephones and pneumatic bells, besides experimental apparatus of nearly every description are here described. It is satisfactory also to note that the prices of chemical and physical apparatus show a decided tendency downwards. We may be permitted to congratulate the firm in question upon the energy and ability with which their business is carried on.

ELECTRIC LIGHTING IN THEATRES.—Mr. Augustus Harris raises an objection to electric lighting on the ground of possible heating of the wires. To him replies, very sensibly (in the columns of the *Daily News*), one who signs himself "Electrical Engineer," and who writes as follows:—"I must say Mr. Harris's reason for objecting to the electric light, 'because there is great danger in it should the wires get heated,' is just as reasonable as if he were to say, I object to the use of cranes to lift heavy weights because the chain might break. Chains do not break if they are made sufficiently strong for the weights they have to suspend, and electric light wires do not get heated if the cable be made sufficiently large for the current. In all modern installations, worked out under the highly serviceable insurance rules, safety fuses are provided, thereby making it absolutely impossible for a fire to occur through the use of the electric light if the rules in force are properly carried out under competent and responsible supervision."

THE PYRO-MAGNETIC DYNAMO.—We confess we do not quite know what to make of Edison's direct-heat-conversion-into-magneto-electric-energy machine. The difficulty that will immediately present itself to everyone is to understand how the decrease in the temperature of the iron during the fraction of a second in which it is screened from the hot air blast can possibly be sufficient to produce so marked a change in its magnetic permeability. The screen rotates at the rate of 200 revolutions per minute; it therefore appears that the hot air passes through the iron tube for about one-sixth of a second, and is screened off for an equal period. It is true that the tubes are made of very thin iron; but this cuts both ways, for the magnetic resistance will be greater and the electrical efficiency (owing to the increased periphery) less in proportion. We can only say—as Prof. Perry said the other day in discussing Forbes's meters at the British Association—that we cannot too much admire the courage and skill with which the inventor has attacked the problem upon lines on which success would to ordinary minds have appeared so hopeless. However, any modicum of success in the direction of the immediate conversion of heat into electric energy is of such enormous importance that we would fain believe in the reality of the achievement. Illustrations of the machine will be found in another column.

TELEPHONY IN THE TEES DISTRICT.—Owing to the large increase in the traffic on their lines the Northern District Telephone Company have recently provided entirely new switching apparatus, and also made great alteration in the working of their exchange system in this district. At Stockton and Darlington the new arrangements have been in operation for some weeks, but the principal part of the work, namely, that at Middlesbrough, was only completed within the last few days. This involved the alteration of about 160 wires, of which more than half had to be newly erected. In addition to this, all the switch-board arrangements had to be altered. The work had to be completed between the hours of 3 o'clock on Saturday and 9 o'clock on the Monday morning, so as not to interfere with the working of the subscribers' lines; and it is highly creditable to the engineer-in-charge (Mr. E. R. Widdicombe) and his staff that the whole of the work was carried out without a single hitch. The Trunk system of the company has recently been considerably extended, and communication can now be had from Middlesbrough, South Stockton, East and West Hartlepool, Sunderland, Newcastle, North and South Shields, Tyne Dock, Blyth, Durham, Bishop Auckland, and Darlington. There are also now two distinct routes from Newcastle to Middlesbrough, viz., *vid* Durham, Bishop Auckland and Darlington, and *vid* Sunderland and Hartlepool, so that it is almost impossible for communication to be entirely interrupted.

PROFESSOR SCHUSTER'S EXPERIMENTS.—In connection with the results announced by Prof. Schuster as to the difference of potential between a metal surface and a gas in contact therewith, it is interesting to note that in the year 1878 (*Proceedings* Royal Society, March 21), Profs. Ayrton and Perry wrote as follows:—"In fact we have good reason to believe that there is no great difference of potential between a metallic or liquid surface and the air in contact with it." These views were, however, attacked by Clerk-Maxwell in a letter to this journal (*Electrician*, April 26th, 1879), who, writing in his good-humoured, bantering way, said, "A statement like this, coming from men whose scientific energy is threatening to displace the centre of electrical development, and to carry it quite out of Europe and America to a point much nearer to Japan, is worthy of all attention, even without an explicit statement of their 'good reason.'" And Maxwell went on to show the difficulty of reconciling this view with the well-known experiment of Mr. J. Brown on the contact potential of iron and copper in an atmosphere of hydrogen-sulphide. Shortly after, and no doubt in part in consequence of this argument, Ayrton and Perry seem to have abandoned the position they had taken up. For the benefit of those of our readers who may have missed Prof. Schuster's experiments, we may note that they show very strong reason for believing that "there cannot be a finite difference of potential between a gas and a metal in contact greater than one-quarter of a volt."

SIR WILLIAM GROVE.—The announcement of the retirement of Sir William Grove from the judicial bench affords a welcome opportunity for a brief recapitulation of the leading facts in the scientific career of one who has afforded a singular example of eminence in such apparently divergent paths. The musty, crabbed ways of legal lore might be supposed to have little attraction for a mind capable of the broad generalisation which characterises Sir Wm. Grove's most important contributions to science. Yet the Law was his first love, and to its study he returned with unabated ardour after nearly 20 years' devotion to science. In 1835, while reading for the bar, Mr. Grove (as he then was) was attacked by a slight illness which caused him to lay aside his law books and seek recreation in science. The early result was the discovery of the nitric acid battery, which for many years remained the most powerful source of dynamic electricity, and which we have the authority of Prof. Forbes for asserting, remains (without Eclipse)

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about the very best primary battery for electric lighting to the present day. From 1840 to 1847 he occupied with distinction the chair of Faraday as Professor of Natural Philosophy at the Royal Institution, and during this period he wrote his great work "On the Correlation of the Physical Forces." In 1866 he was chosen President of the British Association, which sat that year at Nottingham. His presidential address on the continuity of natural phenomena ranks amongst the most famous of the series. Sir William is a member of the council of the Royal Society, and has received numerous distinctions from foreign academies. In 1853 he "took silk," led the South Wales and Chester circuits, and eventually rose to the Bench, of which he has since been one of the most distinguished ornaments.

THE "SPECIMEN GALLERY" AT THE BRITISH ASSOCIATION. In the "Specimen Gallery" set apart at Owens College for the reception of exhibits in connection with the British Association meeting, the principal interest for electricians centred in the new electric light measuring instruments of Sir William Thomson. These instruments were described and illustrated in this journal in the month of May. There were now exhibited a direct-reading vertical-scale voltmeter, a marine voltmeter, and a standard electric balance. Mr. Killingworth Hedges exhibited several cells of the Phœnix zinc-lead secondary battery, which were used for lighting some small lamps. Messrs. Glover and Co. showed a complete set of samples of the insulated cables which they had manufactured specially for the lighting of the Manchester Exhibition. Some specimens of soldered joints in large cables were shown, and side by side with these there was an instructive display of "how not to do it," consisting of a large number of faulty joints which had been cut out of cables of all sorts and sizes, and had been in actual use in electric lighting installations. The principal faults displayed by these joints were (1) lack of sufficient length—that is, the overlapping and twisted ends were generally too short to give sufficient area of contact; (2) neglect of the use of binding wire, which is very necessary in case of joining strands of large sized wire; and (3) imperfect soldering. In the latter case it was often evident that the joint had been made with the wire already in position, and consequently while one side of the wire had been perfectly coated with solder, the inner or lower side had almost entirely escaped. In joining heavy cables it is almost impossible to make a good job unless there be sufficient slack to get all round the joint. This is a point which should be carefully looked at in wiring.

THE LIGHTING OF THE GLASGOW BAZAAR AND CITY HALL.—At a meeting of the Glasgow Town Council a discussion took place upon the report of the committee which has recommended the lighting of the Bazaar and City Hall by arc light. The estimated annual expenditure was not to exceed the present cost of gas lighting, which amounted to £500 per annum. Mr. Brysom had prepared an estimate for the first cost of plant, which he put at £1,800. Mr. Simons opposed the recommendation of the committee on the ground that their proposals were of too vague a character. He also denied that the present cost of gas lighting amounted to £500 a year; from figures supplied by the gas office he found that it had been less than £300 for several years past. The first idea of using the electric light arose when it was under contemplation to light the City Hall, the Bazaar, and the new municipal buildings all from one central station. Circumstances had now altered, and the entire scheme had been changed. So far as he knew, no public building so large as the City Hall had been lighted with the arc light. Where electric lighting had been adopted it was by means of incandescent lamps. Ultimately, an amendment, moved by Bailie Macfarlane and carried by a majority of one vote, was adopted in the following terms:—"That it be remitted back to the committee to submit a statement of the cost of the plant and annual expense of the electric light, and, further, the relative cost of gas lighting by the modern and improved system." With regard to Mr. Simons' implied preference for incandescent lighting, no doubt there is much to be said upon his side, but we have never before heard it suggested that a building was too large to be lit by arc lamps. Mr. Simons doubts whether any building so large as the Glasgow City Hall has ever been lit by arcs. Well, to mention only one example, there is the Olympia Hall, at Kensington. Is the Glasgow Hall so very much bigger?

PRECAUTIONS AGAINST FIRE IN THE THÉÂTRE COMÉDIE FRANÇAISE.—At the present moment, when the appalling catastrophe at Exeter has once more peremptorily called attention to the urgent necessity for reform in the arrangements of our theatres, it will be opportune to describe a device which has just been brought into use at the Comédie Française, and which, had it been available at Exeter, would doubtless have been the means of mitigating, if not of entirely preventing, the worst features of the catastrophe. It is universally admitted that the means of securing the maximum degree of safety in theatres are chiefly:—(1) Proper structural arrangements; (2) Electric lighting; (3) The provision of an iron curtain completely separating the stage from the auditorium. The Comédie Française is at present only partially lit by electricity; but the work of extending the installation is now in active progress. It is, however, in the matter of the arrangements for manipulating the iron curtain that electrical appliances have been called upon to solve some of the chief difficulties hitherto encountered. These difficulties have arisen from the fact that the raising and lowering of the curtain has hitherto been a slow and somewhat difficult operation, and fears have been expressed that at the critical moment the manœuvre would fail to come off. The arrangement in force at the Comédie Française, which was devised by M. Edoux, provides hydraulic power for working the curtain, and matters are so arranged that the descent is effected by merely closing an electric contact; push buttons are consequently provided in various parts of the house, so that on the outbreak of a fire the very first duty on the part of the discoverer would be to lower the curtain. Moreover, to ensure that the whole of the appliances shall be maintained continually in readiness for instant use, the front of the curtain itself is painted as a "drop-scene," and the descent is effected every evening during each *entr'acte*. The time of descent is only very little longer than with a curtain of the ordinary description. The arrangement appears to be in every respect a desirable and successful one, and its first application at the theatre in question was greeted with a storm of applause.

EDISON'S MAGNETIC WHEATSTONE BRIDGE.—In another column will be found a description of a magnetic balance devised by Edison on the lines of the Wheatstone bridge. Since Kapp set the example of considering magnetic problems as analogous to the corresponding electrical problems under the added condition of a conducting medium, it has been evident that certain magnetic questions might be solved in this way, at least to a first degree of approximation. A little ingenuity would, for instance, probably discover methods of determining the magneto-motive force of a permanent magnet in terms of an electro-magnet with a given number of ampere turns after the analogue of Poggendorff's (or some more suitable), method of determining E.M.F., and similarly with internal and external magnetic resistance and so on. But as the result

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would in general be capable only of about the same degree of approximation as would be obtained if the electric apparatus were plunged into a saline solution, it is scarcely reasonable to expect results of any great value. In making these observations we do not mean to imply that Edison's bridge is not fully entitled to a very respectful consideration. It will, however, probably be the general opinion that the arrangement is less convenient and certainly not more accurate than other well-known methods of determining the magnetic qualities of iron. A great difficulty in the use of the instrument would arise from the fact that the proportion of "leakage lines" will be upset when the bars to be compared are not of the same dimensions, or when their end contacts are not equally good, or when they are not of the same magnetic quality throughout. We should, however, much like to see some comparative test carried out upon a set of iron bars, first with Edison's bridge, and afterwards by one (or more) of the methods in ordinary use. As to the latter, it may be worth noting that one of the leading firms in this country has for many years employed the somewhat unorthodox method of testing the relative magnetic qualities of different samples of iron by their relative lifting power. Under proper precautions it is found that this method yields results which are perfectly concordant with those obtained by the use of Hughes's balance.

SCIENTICULISSIMUS AMERICANOS.—In America—as elsewhere—there are two kinds of "electricians," those who do the work and those who do the talking. The former variety happily far outnumbers the latter, and whatever may be their presumed theoretical shortcomings they are entitled to, and have always received from us, the substantial credit which is due to substantial success. For the latter variety we confess, as a rule, to have less sympathy. A story is told of one gentleman—whose name, by the way, is dignified by a prefix held in high repute on this side of the water, though we do not suppose that the title is of English origin—that at the time when Edison was known to be seeking to perfect the original platinum filament glow lamp the hero of the tale heard of the success which Pictet and Cailletet had achieved in solidifying hydrogen. With generous ardour, and in all good faith, he at once telegraphed to Edison suggesting that solid hydrogen would most probably prove to be the very thing he wanted for lamp filaments. This conception of a red hot hydrogen filament in a high vacuum will, we are sure, be admitted to be one of the most suggestive ideas that has ever been placed before the scientific world. The story is, moreover, easier to believe after reading some remarks made by the same individual in a discussion on Mr. Reckenzaun's paper on "Storage Cells" at the recent meeting of the American Electric Light Association. Mr. Reckenzaun was asked what was the rate of loss of energy in a battery when standing idle, and having replied to the question the meeting was further enlightened by the following learned and brilliant observations from the individual referred to:—"That result is exceedingly interesting, because it suggests something that was done by Faraday in determining the length of time that would elapse before a vacuum would be absolutely destroyed. It was there determined that it would take about one year for a Torricellian vacuum to disappear; so we have this action really verifying that. It is possible to keep it charged in that way for two years, you say, and still allow of some residual charge." The notion that the rate of loss of charge of a storage cell is intimately connected with the rate of leakage into a Torricellian vacuum is, again, one of those things which no ordinary mind can compass. But in the wildest vagaries of this scientific genius (of which, by-the-bye, we have several further specimens at hand) there is invariably a tone of geniality and good faith which leads us to esteem the individual even when we can only smile at the science. Occasionally we come across specimens, apparently belonging to the same species, of which the same remark cannot honestly be made.

THE EFFECT OF HEAT ON MAGNETISM.—In the September number of the *Phil. Mag.*, Mr. Herbert Tomlinson continues his account of researches on the physical properties of iron. He has now investigated the very interesting question whether the phenomenon of "recalescence" is or is not associated with the sudden loss of magnetic power which iron undergoes at a certain temperature. The investigation, therefore, comes very opportunely at a time when Edison is attempting to utilise the latter phenomena for industrial purposes. It may be as well to give in a few words the history of the subject. In the year 1869, Mr. Gore brought before the Royal Society an experiment which showed that when iron had been raised to a bright red heat, its contraction on cooling did not proceed uniformly, but at a certain temperature it suddenly and momentarily expanded. In September, 1873, Prof. Barrett extended the observation by showing that the momentary expansion was accompanied by a momentary flash into more vivid redness, and further, that the effect was not obtained unless the iron was previously raised to a temperature considerably higher than that at which the visible effect takes place. The experiment can easily be made with a Bunsen burner and a sewing needle. Prof. Barrett was of opinion that this phenomena—which he called "recalescence"—was associated with the loss or gain of magnetic properties. If this were true it would evidently tell seriously against the pyro-magnetic dynamo. Mr. Tomlinson, working with more elaborate means of research, has arrived at the conclusion that "it by no means follows that the phenomenon of recalescence occurs with *every* specimen of iron at the critical temperature at which iron loses its magnetic properties;" and remarks that he has sometimes noticed "*more than one* evident accession of heat during the same cooling." The important observation was made that in very soft iron wire molecular disturbance (evinced by change of volume) occurs at a much higher temperature on cooling than with harder specimens, and recalescence does not then manifest itself. We are not aware that any observations have been made as to the difference between hard and soft iron (or steel) in respect of the temperatures at which their magnetic properties are lost. Mr. Tomlinson is silent upon this point. The conclusions arrived at are thus summarised at the end of the paper: (1) There are two distinctly marked critical temperatures for iron; the lower somewhere about dull red, and the higher somewhere about bright red. (2) At the former of these critical temperatures the iron begins suddenly to lose its magnetic properties if it is being heated, and to gain them if it is being cooled. (3) At or *near* the latter critical temperature the iron, on being heated, if under the slightest torsional, longitudinal, or flexural stress or strain, begins to exhibit a remarkably sudden change. If the metal be under stress, the sudden change resembles that which would result from a sudden increase of elasticity. If the metal be permanently strained, there is a sudden increase in the amount of the strain. (4) When the iron is cooling a sudden change, but opposite in direction to that which occurs on heating, takes place. The temperature at which the sudden change takes place is, for very well annealed iron, nearly the same as that at which the change takes place on heating. If, however, the wire be not annealed, the change may be delayed by the so-called coercitive force of the metal until the lower critical temperature is reached. When the change is so delayed, the phenomenon of recalescence occurs.

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THE SAFETY OF ALTERNATING CURRENTS.—If half of what we hear on this subject from America is true, it will be proper in future to speak of the safety rather than the danger of alternating currents. Prof. Houston has already told us how he has several times taken shocks of 1,800 or 2,000 volts (alternating) and felt little the worse. Now we have Mr. Smith, of Alleghany City, telling a long story about a lineman who got hold of a wire under a thousand volts and was unable to leave go until rescued after the lapse of *four* minutes. "By the time the ambulance got there he was sitting up and refused to go in the ambulance, and also refused to go to the doctor, seeming to be very much disgusted to think that an old man like himself should not be able to stand a thousand volts. His hand was pretty badly burned, but the next day he expressed himself as being perfectly well and able to go to work. He said he felt no particular pain when he first got hold of the wire, and was perfectly conscious for the first two minutes, but was unable to call out for assistance or to let the wire go; after that he simply forgot everything." This seems to us to be a highly remarkable case, which should be noted for future reference. On points of manipulation Mr. Smith, of Alleghany City, was equally instructive. "We have satisfied ourselves," he said, "that for alternating current conductors, if we can get a good metallic covering, it is about as good as anything that is to be had. In some parts of the streets we found it difficult to lay the wooden boxes, and we used iron pipes through which we pulled the cables and filled the pipes with pitch to prevent the average Irishman from driving his pick through them. We have not had the slightest trouble from loss of current or anything else. Yet our men handle those cables with perfect impunity. I understood that some experiments had been made by the Westinghouse Company with regard to insulation. I made some inquiries of them, and their answer was that we could use any kind of cable that we wanted to as long as the covering was good; but for practical reasons they should recommend to us in this particular instance a lead-covered cable, having both conductors in one lead covering. The question was raised as to whether our men would not be liable to get shocks from the covering of the converters if they were not grounded. We tried it and found no effect whatever. I have had no experience with a long conduit of iron. In the case of some telephone lines we found that if we crossed the wires every fourth or fifth pole we had no effect whatever from the current. In one case there was a double service of 7in. apart. We have had no trouble. There is a continuous musical note, which, however, is much less annoying than the buzzing from the ordinary machine. This crossing of the wires was done by us because they happened to be our wires. Of course we think that telephone companies ought to cross their wires themselves. Another thing: On these machines there is so little wear on the armature that the discharge is not so heavy. [Here we do not quite follow Mr. Smith.] The instant you break the circuit you are safe. There is so little shock that it does not amount to anything. Our linemen do our splicing without the slightest difficulty. We never think of shutting down the machines for them to splice up. Sometimes a man will say, 'It has been pretty hot up there to-day.' But they never complain of having any real trouble. They say that they would rather splice a 1,000-volt alternating wire than one in a 60-light Brush machine."

"LUMINOID" INCANDESCENT LAMPS.—A new incandescent lamp, called the Mace or "luminoid" lamp, has been introduced by the Vitrite and Luminoid Company in America. According to the *Western Electrician* Mr. Walter T. Goolden, M.A., F.C.S., reports that after a photometrical and electrical examination, conducted under his superintendence, of various samples of luminoid lamps submitted to him during the past six months, and after witnessing and examining the process of manufacture, he had formed a favourable opinion of the merits of the lamp on the following points:—1. Constancy of illuminating power throughout its life. 2. Durability under current. 3. Strength and elasticity. 4. Facility and cheapness of manufacture. In regard to the first point, he cites the following instances in support of his opinion that the lamp is superior to any in the market: "November 1st, 1886, two lamps were examined, marked 70 volts 20 candle-power. These had been running for over 1,500 hours at 70 volts, the volts being measured by a Cardew voltmeter, for whose correctness I am able to vouch. The test showed that at 70 volts they each took an average current of ·96 ampere, and gave 22 candles. Presumably, therefore, they had not lost candle-power by their long run, their efficiency at this pressure being 3·1 watts per candle. On the same day a batch of lamps were tested by me previous to running. They were then run for 912 hours, and again tested, the results being given in the appended table. The lamps were marked 45 volts 16 candle-power, and they were in both cases tested at 16 candle-power:—

Distinguishing Mark.	Before Running.		After Running.	
	Volts.	Amperes.	Volts.	Amperes.
1	44·0	1·32	44·5	1·36
2	43·0	1·31	43·0	1·30
6	45·2	1·31	45·0	1·25
7	46·0	1·35	45·0	1·34
8	45·5	1·38	45·5	1·30
Average	44·7	1·33	44·4	1·31
	Watts per candle 3·7.		Watts per candle 3·6.	

"Thus the lamps show no falling off in candle-power or efficiency after a long run, which would admittedly have reduced the light of the lamps of the best English makers by from 25 to 50 per cent. With regard to the durability of these lamps, while it is impossible to speak absolutely, from the absence of specific evidence, I may point out that the above named tests certainly tend in this direction, and that from what I know of the constitution of the filament, I may predict with considerable confidence that it will prove very superior in this respect to a carbon filament pure and simple. The filaments are remarkable strong and elastic, several of the lamps which I have seen having come from America in the ordinary post, without accident or damage to any of the filaments. The filaments of these lamps also present very marked physical differences to those of ordinary carbon filaments, some of them sustaining a full current for some little time in the air—from two to three minutes—before giving out. The process of manufacture, which I have seen and studied, compares not unfavourably with known modern processes of lamp manufacture in point of quickness and expense. I may say that nearly all the luminoid lamps tested by me have shown signs of careless manufacture, the vacuum being usually very imperfect; and the lamps in other ways gave evidence of bad workmanship. It is certainly remarkable that under such conditions the new luminant should present such a marked superiority to lamps made with all the skill attained by English manufacturers."

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ON COPPER WIRE.*

BY W. H. PREECE, F.R.S.

At the (1885) Aberdeen meeting, in Section A, I gave some results of the behaviour of copper wire between London and Newcastle, showing how remarkable is its mechanical strength when hard drawn and pure, and how it is virtually free from those effects of electro-magnetic inertia which tend to throttle the flow of electricity through iron wires. The success of that experiment has led to the erection of four copper wires all the way from London to Dublin, in connection with a new cable laid between Nevin in North Wales, and Newcastle, near Wicklow. The result has exceeded our most sanguine anticipations, and its influence on speed of working will be referred to in a succeeding paper.

The wire used for the Welsh line is No. 12½ B.W.G., ·097in. in diameter, or 97 mils., weighing 150lbs. per mile, and giving a specified resistance at 60deg. F. of 6·05 ohms per mile. Its breaking weight was specified to be 490lbs., which is equivalent to 29½ tons per square inch.

The total length of the line between London and Nevin is 270·8 miles, of which 17·34 miles are underground. The resistance per mile when erected was 5·695 ohms at 30deg. F.

The capacity per mile was ·01319 microfarad and insulation per mile at 30deg. F. 70 megohms.

The following table summarises the elements of the different copper wires used in the Post Office :—

HARD COPPER WIRE.

Weight per Statute Mile.			Approximate Equivalent Diameter.			Minimum Breaking Weight.	Minimum Number of Twists in 3 inches.	Maximum Resistance per mile at 60 degrees F.	Minimum Weight of each Coil of Wire.
Required Standard.	Minimum.	Maximum.	Standard.	Minimum.	Maximum.				
lbs.	lbs.	lbs.	mils.	mils.	mils.	lbs.		ohms.	lbs.
100	97½	102½	79	78	80	330	30	9·10	50
150	146¼	153¾	97	95½	98	490	25	6·05	50
200	195	205	112	110½	113¼	650	20	4·53	50

The wire is subject to very strict inspection. It is carefully gauged and tested for ductility and tensile strength. It is wrapped in six turns round its own diameter, unwrapped and again wrapped in the same way; and it must do this without breaking. A piece is then gripped by two vice at a distance from each other of 3in., one being fixed and the other slowly revolved until the wire breaks. The number of twists the wire withstands is shown by an ink mark put on the top of the 3-inch piece before the test commences and which forms, as the wire is twisted, a spiral on the wire whose number of convolutions are easily counted.

The test for tensile strength is made by the direct application of a stress slowly augmented until the wire breaks.

The following table gives a record of some recent tests made at the Oakamoor Works of Messrs. Bolton and Sons :—

No. of Test.	Diameter in Mils.	No. of Twists in 3″.	Wrapping and unwrapping round own diameter.						B.W. lbs.	Resistance per Mile at 60° F. in ohms.
			On.	Off.	On.	Off.	On.	Off.		
Specification	97·0	25	6	6	6	...	...	...	490	6 05
1	97·5	30	6	6	6	6	6	...	510	.....
2	...	25	6	6	6	1	...	...	503	.....
3	97·4	40	6	6	6	6	6	...	508	.....
4	98·0	41	6	6	6	3	...	...	520	.....
5	97·5	27	6	6	6	6	6	...	520	.....
6	...	28	6	6	6	6	4	...	515	.....
7	97·9	25	6	6	6	1	...	...	515	.....
8	98·0	30	6	6	6	1	...	...	520	5 750
9	97·5	44	6	6	6	6	6	...	510	.....
10	98 0	45	6	6	6	3	...	...	520	.....
11	97·5	24	6	6	6	1	...	...	508	.....
12	...	27	6	6	6	6	6	...	512	5·878
Averages ...	97·5	32·16	6	6	6	6	...	...	*513·41	5·814

* N.B.—This equals 30·6 tons per square inch.

* Paper read before the British Association Meeting at Manchester, September, 1887.

It will be seen that the tests in all cases exceed the specification figures. The average resistance was 5·814ω per mile, and this, for 97·5 inch diameter, is equivalent to 98 per cent. of pure copper.

So much depends on the care and accuracy with which copper wire is erected that an entirely new mode of wiring or putting up the wire has been introduced. Hitherto it has been customary to regulate the sag of iron wires by reference to a dip of 24in. in 100 yards, and to vary this for different spans and different temperatures by reference to tables. But foremen were governed very much by rule of thumb and regulated simply by eye. This would never do for copper, so special dynamometers or draw vice have been designed and fitted with Salter's springs, properly graduated, and the wire is always regulated to the proper tension.

The following table shows the corresponding sags and stresses of iron and copper wires under varying temperatures. It is based on the present specification for each form of conductor, and is calculated to allow a factor of safety of 4 :—

TABLE SHOWING SAGS AND STRESSES WITH VARYING SPANS AND TEMPERATURES FOR IRON AND COPPER WIRES.

——		At 22° Fahr. Low Winter Temp. (Hard Frost.)		At 40° Fahr. Ordinary Winter Temp.		At 58° Fahr. Average Summer Temp.		At 76° Fahr. High Summer Temp.	
Description of Wire.	Span	Dip	Stress	Dip	Stress	Dip	Stress	Dip	Stress
	Yds.	ft. in.	lbs.	ft. in.	lbs.	ft. in.	lbs.	ft. in.	lbs.
*No. 7½ Iron	100	3 1⅞	270	3 9	227	4 3½	200	4 8⅞	180
	90	2 6⅝	270	3 1⅝	219	3 2⅝	190	4 0⅛	169
	80	2 0¼	270	2 7⅛	210	3 0⅛	178	3 5⅝	157
	70	1 6½	270	2 1¼	198	2 6½	164	2 10⅛	143
	60	1 1⅝	270	1 8	184	2 0⅛	148	2 4⅛	128
	50	0 9½	270	1 3⅛	165	1 7⅜	130	1 11¼	119
No. 10½ Iron	100	3 1⅜	135	3 9	113	4 3½	100	4 8⅛	90
150lbs. hard drawn Copper, No. 12½.	100	2 8	120	3 7	89	4 3⅞	74	4 11½	64
	90	2 2	120	3 1	84	3 9½	69	4 4½	60
	80	1 8⅜	120	2 6⅝	80	3 2½	64	3 8½	54½
	70	1 3⅝	120	2 1⅜	73	2 8⅝	57½	3 2⅜	49
	60	0 11⅛	120	1 9	66	2 3⅛	51	2 8¼	43
	50	0 8	120	1 4⅝	58	1 10	44	2 2⅝	36½
100lbs. hard drawn Copper, No. 14..	100	2 8	80	3 7	59	4 3⅞	49	4 11½	43

* Factor of safety of 4 at minimum temperature.

The minimum temperature is taken at 22deg. F. Ordinary winter temperature may be taken at 40deg., average summer temperature at 58deg., and the temperature of a hot day at 76deg.

These figures serve the same practical purpose as the use of thermometers, which, if placed in the sun, would not as a rule record the actual temperature of a wire in course of erection.

The stress, as measured by the new dynamometers, should in all cases correspond with that shown in the table for a given conductor and average span under the temperature prevailing during the erection of the wire. This stress will vary for different spans at the same temperature; but the figures opposite the average span for any given line and temperature are those employed in practice.

Sags and stresses for copper and iron wires do not vary in the same ratio under changes of temperature owing to copper having a higher coefficient of expansion than iron. With spans of less than 80 yards the difference is not so great as to render it unsafe to run iron and copper wires together, but as spans increase beyond this length some danger of contacts may arise, and a slight departure from the tabular results may then be permitted to obviate this difficulty. For example, in special instances the copper may be run with a greater dip or the iron with a lesser one. It is, however, better not to run copper and iron together on spans exceeding 80 yards.

In drawing up this table the following formulæ were employed :—

$$d = \frac{a^2 w}{8t}\,;\quad d = \sqrt{\frac{3a(s-a)}{8}}\,;\quad s = a + \frac{8d^2}{3a}\,;\quad t = \frac{a^2 w}{8d}\,;$$

where a = span, d = dip, t = stress at insulator, w = weight of unit length, and s = length of wire in span.

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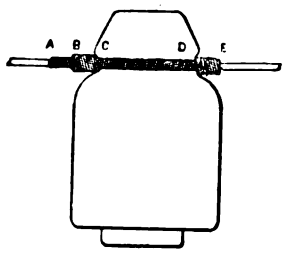
Coefficient of expansion for iron = ·0000123 per deg. C.
" " copper = ·0000172 " "
w for 400lbs. iron = ·075758 per foot.
" 150 " copper = 028409 " "
" 100 " " = ·018738 " "

The wire is bound to the insulator by finer copper wire, and a sample of the way this is done is shown on the table.



Two wires are whipped round the line wire from B to E, thence back to D; then from the *upper* side of the line wire they are taken round the neck of the insulator to the *under* side of the line wire at C, back over the first layer to B, and then taken on as a single layer to A.

The length of wire required for each binder is :—
For 150lbs. line wire .....52 inches.
For 100lbs. " .....40 "

The binding wire weighs 50lbs. per mile, and is No. 17½ B.W.G.

Copper wire requires very careful handling. Flaws, indentations, scratches, kinks, and similar injuries act very much in the same way as diamond scratches on glass. Special drums, fitted with breaks, have been designed and made so that the coils of wire may be *unwound* under tension, like a reel, to prevent the possibility of kinking, or putting unnecessary turns in the wire.

The joints are the ordinary Britannia joints, whipped with No. 20 tinned wire, chloride of zinc or Baker's fluid being used as a flux for soldering. It is only necessary to avoid the continued application of heat, for heat softens and weakens the wire; quick soldering is therefore essential.

Copper wire being practically free from electro-magnetic inertia or self-induction, its time constant, or the amount of retardation it exercises on the rate of flow of electricity, is simply the product of its capacity K, and resistance R.

K R for 400lb. iron is ..... ·2116 per mile,
and for 150lb. copper is ..... ·0786 "

But iron has electro-magnetic inertia, which still further retards the rate of working; and therefore the speed on a copper aerial line ought to be at least three times greater than that of an iron line.

This influence of self-induction is extremely difficult to explain. An analogy sometimes assists explanation, but it more often makes confusion worse confounded.

Supposing we had a water pipe of circular section, made of some material which was remarkably sensitive to cold, and which would contract in section along its whole length with the slightest motion of the water, and that the amount of this contraction varied with the rate of motion of the water, then when the water commenced to move, the circular section of the pipe would diminish in area, the flow of water would become checked, and the faster the water flowed the more the passage would become choked, therefore the less quantity of water which would be discharged in a given time. This is analogous to the effect of self-induction in a circuit conveying rapidly alternating currents of electricity; the whole passage becomes choked throughout its length, and less electricity is discharged in a given time. In the former case, it is as though the head driving the water through the pipe were diminished; in the latter case, it is as though an opposing E.M.F. were set up in the wire diminishing the value of the original driving power. In each case the effect may be said to be due to the creation of a spurious resistance to the motion set up by the motion itself. The effect of friction on the flow of fluids is by no means dissimilar to that of self-induction. Anyhow, this self-induction, or as it is better known in its general sense, *electro-magnetic inertia*, is a serious hindrance to rapid telegraphy and to long-distance speaking on telephones. It has now been practically eliminated from the line by the use of copper wire, and no other material should be used for telephones. The so-called Phosphor and Silico bronzes, when of high conductivity, are in reality very nearly pure copper, and may be classed with copper.

We are now erecting a new copper wire from London to Newcastle, another from Newcastle to Leith, and a third from London to Doncaster.

We have put up 350 tons of copper during the last three years.

DISCUSSION.

Sir FREDERICK BRAMWELL asked what was the variation in practice in the tension of the wire both in iron and copper with such ranges of temperature as were ordinarily or extraordinarily met with in this climate. He would also like to ask what was the objection to attaching the wires to a spring on the pole which would yield with a definite tension, which tension would not be much increased within the small range needed to maintain the catenary.

Mr. PREECE said that the ranges of stress in iron wire varied from 270lbs. in winter to 180 in summer, and the difference of dip or sag was from 3ft. 1in. in winter to 4ft. 8½in. in summer (per 100 yards). In copper the range of stress was between 120lb. in winter to 64 in summer, and the difference in dip given was from 2ft. 8in. in winter to 4ft. 11½in. in summer. With regard to the suggestion made, he thought it would be impracticable, because it would be essentially necessary to have a joint on every pole, and although a joint offered practically no resistance it was a thing to be avoided.

Sir FREDERICK BRAMWELL said that all he suggested was that there should be a piece of slack wire between one spring and another, and it seemed to him that if that were done a much more uniform stress would be attained than was the case at present. He thought it would be most desirable that Mr. Preece should turn his attention and that of the staff under him to the important question of hanging wires so that London might not be placed in the awkward position it was in last winter. There ought to be no difficulty in solving the problem.

Mr. RICHARDSON commented on the cheapness of copper, and said that this was a favourable time for substituting it for iron.

Major-General WEBBER asked whether Mr. Preece's experience had afforded him any results as to when the copper wire which was now used by the Post Office began to stretch so as to affect seriously the regulation of the wires, and whether any comparison had been made between copper and silicon bronze wire in that respect. The subject raised by Sir F. Bramwell had occurred to telegraph engineers twenty years ago, and he (the speaker) fully endorsed what Mr. Preece said from the construction point of view.

Prof. PERRY thought that General Webber did not quite apprehend the way in which Sir Frederick Bramwell intended the spring attachment to be made. The suggestion was to employ a slack wire between two gripping springs without a break. He thought there was sufficient genius among electrical and telegraph-engineers to have evolved that method long ago had there not been some practical objections. Prof. Perry next referred to a method of testing the tension of a wire by counting the number of vibrations it gave under different tensile conditions, and said that it was one which gave the most accurate results.

Mr. PREECE said it was a very difficult thing to answer a practical suggestion like that made by Sir Frederick Bramwell. He was bound to admit that it was a suggestion that deserved serious consideration. But Sir Frederick's argument seemed to be based principally on the fact that the wires, especially in the earlier part of the year, were lying about broken for weeks in London. He might say that the trouble arising from snowstorms and tempestuous weather did not affect the Post Office system, with which he (the speaker) was immediately connected, for in all large cities, without exception, their wires were placed underground, and in large cities that was the only practical and proper way to deal with the question of danger from overhead wires, if there was any danger. For the forty years during which telegraph wires had been overhead there had been only two instances of loss of life (which he specified), and those two were solely due to carelessness. The cry of danger that was raised from overhead wires was all moonshine. It was formerly the practice of the linemen, by means of their winders, to tighten the wire at every quarter of a mile in summer, and to slacken it in winter; but this was found to be an unnecessary trouble. If it were simply a case of snow adhering to the wire no harm would arise, for the wire would be strong enough to bear the weight of the snow; but when the snow was accompanied by a gale of wind, blowing at a pressure of 15lb. to 20lb. per square foot, the tension of the wire became so great that it would carry away Sir Frederick Bramwell's tension regulators, posts, and everything. During the gale they experienced in the early part of the year, when the snow, wind, and frost conspired together, poles of 12in. diameter that could bear he could not say how many tons per square inch of pressure were swept down like matches, and his experience when those snowstorms came (which they only did, fortunately, once in ten years) was that there was no practical device ever suggested that would enable them to get over the difficulty. In reply to General Webber, he might say that the stretch of copper wire was very small indeed, rarely, in fact, exceeding ½ per cent. The wire almost invariably broke before it was stretched to that extent. He drew no distinction between copper and silicon bronze. All the wires that had been supplied as silicon bronze had turned out to be copper, and copper it virtually was. He regarded Prof. Perry's suggestion, that they should see how far his method of vibrations would apply to light wires, as a very good one. He

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went over the particular Welsh lines referred to in his paper with the express object of seeing what influence the changes of temperature had upon the stresses of the wire and the sags, and at a great many different spots he inserted in the line wire a dynamometer, so that they had the direct pull of the wires measured, and he found the results to be eminently satisfactory.

ON THE PRODUCTION OF A CONSTANT CURRENT WITH VARYING ELECTROMOTIVE FORCE FROM A DYNAMO.*

BY A. P. TROTTER, M.A.

Nearly all the earliest dynamos made for practical work were intended to give a constant current for arc lights in series. Few attempts were made to extinguish separate lights, partly on account of the light being generally required for outdoor work and partly by reason of the contentment with which Americans accept a successful notion without demanding the refinements which are expected in this country.

The problem is to vary the volts when the external resistance is altered, so that the current may be kept constant.

The best known methods are those of Thomson-Houston, Maxim-Weston, and Hochhausen. These rock the brushes on the commutator by means of automatic arrangements on which considerable ingenuity has been expended, and the results, so far as they are applied to arc lighting, are satisfactory.

The armatures of dynamos for series arc lighting are, for several well known reasons, made with less iron and with more wire than those of machines used for other purposes, and a high resistance both of armature and field coils, together with a considerable amount of induction and heating, are, as a rule, inseparable from dynamos for arc lights, and although such proportions preclude the possibility of a high efficiency in the dynamo, it is generally considered that these losses are made up for by the economy of a small conductor and the simplicity of working with a uniform current. With such armatures, the volts may be reduced by rocking the brushes, and if the proportions of iron and wire are correct, this will produce hardly any sparking or additional heating.

A constant current is required for several other purposes than for arc lamps, *e.g.*, the Bernstein system of low-volt lamps in series, certain applications of motors, and for electro-deposition with baths in series. For such purposes there would be no advantage in using a small quantity of iron in the armature, unless to enable the brushes to be rocked, an advantage which would be dearly bought by the low efficiency.

Several attempts have been made to produce a constant current by compound winding, but they do not appear to have met with success. In such a machine the characteristic should be a vertical straight line, but practically it is merely the usual rounded extremity of a shunt characteristic, and the current is therefore only approximately constant. The winding is nearly all shunt, with a few turns of series coils, which are of little use, since it is never necessary to short-circuit the machine, the minimum work being one arc lamp or nothing. The difficulties of insulating, and the expense of winding the fine wire required for high volts would be serious obstacles to compound winding for constant current, even if a fairly constant current could be produced. The method may be worth using for three or four arcs.

Another method has been employed in the Brush system, viz., shunting a portion of the exciting current of the magnets, and thus weakening the strength of the field. It appears that this can be carried farther with a Brush dynamo than with more modern machines. The difficulty is, that if the excitation of the field be reduced to such an extent that its magnetic resistance approaches its initial value, or, considering the saturation curve—when the working point approaches the nearly straight part of the commencement of the curve—the volts become unstable, and the current is liable to drop. If the reduction were very gradual, and the speed perfectly uniform, it might be possible to reduce the volts to a low point if the machine were working on a dead resistance; but with arc lamps it would be impossible, and even with a resistance it is found that from small fluctuations of speed or some other cause the instability is always present.

With an automatic regulator to control the resistances used as a shunt to the field the difficulty increases, for it would attempt to correct a small accidental drop of volts by increasing the strength of the field, and serious hunting would ensue. Arc light dynamos of modern design, by several of the leading dynamo builders, have been successfully controlled by the automatic regulator, to cut down to half the full load with a simple shunt. Instability sometimes is present in shunt wound dynamos used at one time for charging cells, and at another, at lower volts, for running glow lamps direct, the reduction being effected by adding a resistance to the shunt. If such a machine be compound wound, the instability would only be noticed on a small load.

In discussing means for remedying this difficulty, Mr. H. W. Ravenshaw, senior electrician to the firm of Goolden and Trotter, suggested that the reduction might be effected *while the field-magnets were saturated* to the usual point, by diverting the lines of force from their usual path from pole-piece to pole-piece through the armature, by offering a path of lower magnetic resistance. It was proposed to do this by employing a movable mass of iron, which had better be termed a "keeper" (in order to avoid the word armature). The mass of such a keeper would be considerable, and in the course of discussing the mechanical problem of moving it by means of an automatic regulator, the writer proposed, instead of moving it, to neutralise its effect by passing a current round it, thus obstructing the passage of the lines of force through it, and rendering it practically inert, non-magnetic, or altogether abolished.

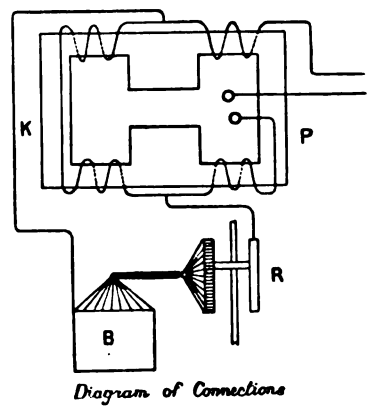

FIG 1.—K Keeper. P Terminals.

The first practical experiment was carried out a few minutes after the invention of the method, with an ordinary series-wound arc lighter of the Gramme type with Goolden-Trotter modifications, and the results were very satisfactory. The double magnet type of dynamo is very suitable for this purpose, for one half of the machine may be constantly magnetised to the desired point of saturation, while the other half acts as a keeper. The former may be called the constantly magnetised limb, and the latter the keeper. They are similarly wound with exciting coils. If when the constantly magnetised limb is fully excited by the usual current through its coils, and no current is passed through those of the keeper, the latter will act as a magnetic shunt, and nearly all the lines of force will pass round and round in a closed circuit of iron. Little or no polarity will be found at the pole-pieces, and there will be a minimum effect on the armature. By allowing a weak current to pass round the keeper the diversion of the lines of force through it will be partially obstructed, and the rest will take their usual path through the armature. With a certain strength of current this obstruction will be complete, and the magnetic effect is the same as though the keeper had been entirely removed from the dynamo. The strength of the field, and its action on the armature is the same as though the dynamo were provided with one magnet only. If now the current through the coils on the keeper be increased beyond this neutral point it will assist the permanent

* Paper read before the British Association Meeting at Manchester, September, 1887.

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magnet; the lines of force in the former will be reversed, and finally when the whole current passes round it, the volts are at the maximum, and the dynamo works as an ordinary series-wound machine.

It was soon found in practice that, owing to the complete magnetic circuit formed by the pair of magnets, the changes in the strength of the field were somewhat sluggish. This was easily remedied by making a gap in the magnetic circuit, by boring out the yoke or side where the magnet bars pass through and bushing them with brass, using brass washers also on the ends of the bars and under the nuts. Experiments have yet to be tried to ascertain the minimum dimensions of this non-magnetic gap. It is important that it should not be too great, not so much on account of the greater expenditure of energy required for the magnet coils, as for the reason that if the magnetic resistance be high it will be impossible to reduce the volts of the machine to a low point. It is evident that the method consists in shunting the useful magnetic field, and the minimum effect can only be obtained by a magnetic short circuit, and the presence of the gap, if of large dimensions, prevents short-circuiting or diversion from being complete. The difference of magnetic potential at the pole-pieces will be practically as great as that at the gap when the keeper is neutral. In the second experiment, in which the gap was introduced, the volts of the machine could not be reduced, for this reason, to less than about one half. It is probable that they can be reduced to from 90 to 95 per cent. without causing sluggish changes.

A practical application has been made of this method for the purpose of running Bernstein glow-lamps arranged in series, and a dynamo controlled on this system by an automatic regulator enables the lamps to be extinguished by short-circuiting. For this purpose an armature of high efficiency can be used, and the current of ten amperes can be maintained constant within 0·2 ampere.

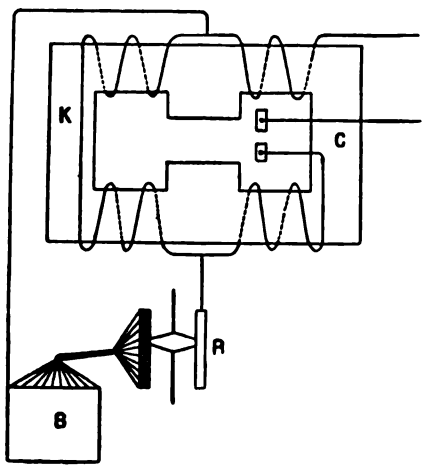

FIG. 2.

C Constantly Magnetised Limb. K Keeper.
B Resistance Box. R Regulator.

It is probable that with this system, armatures of considerably higher efficiency can be used for arc lights, especially as such a nicety of regulation is not required. Experiments have not been carried out far in this direction yet. The system is applicable to dynamos used at one time for charging and at another for running direct, or for any other purpose in which it is desired to reduce the intensity of the field to or beyond such a point as will endanger the stability of the magnetisation.

The practical control of the current in the coils of the keeper has been effected by the mechanical regulator, which may now be said to be a well known appliance. The rheostat is connected to a set of resistances calculated for the particular dynamo.

Curves Figs. 3 and 4 were shown, explanatory of these experiments.

The calculations have been worked out by Mr. Ll. B. Atkinson, and the following is an outline of the method which has been adopted:—

Take a series of values of μ, the number of lines per square inch of armature iron. From this number and the magnetic curve of the material a series of values of magnetic resistance are found. To these add the polar air space resistance, and hence determine the magnetic potential between the poles by multiplying the number of lines by the resistance. This magnetic potential must be equal to the total magnetising force (ampere turns) on the constantly magnetised limb, less the value of lines of force multiplied by the equivalent magnetic resistance, or in symbols:—

$$T_1 - \mu_1 a_1 r_1 = \text{magnetic potential},$$

where a_1 is the area of the limb. But T is fixed and μ_1 can be found. This gives the total lines coming to the poles, and these are equal to the lines through the armature + the lines of leakage between the poles + or − the lines through keeper. Having thus found the lines through the keeper, we find its magnetic resistance for those lines, and the ampere turns necessary are found by the equation

$$T_2 = \pm \mu_2 a_2 r_2 + \text{magnetic potential}.$$

Where T_1 and T_2 are ampere turns, a_1 and a_2 are areas, r_1 and r_2 magnetic resistances of the constantly magnetised limb and of the keeper respectively.

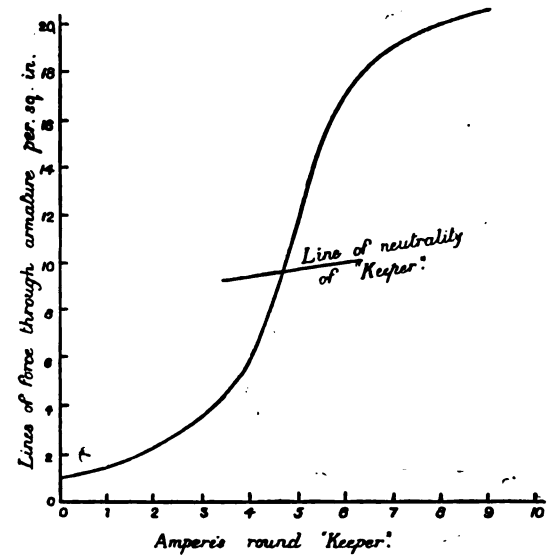

FIG. 3.

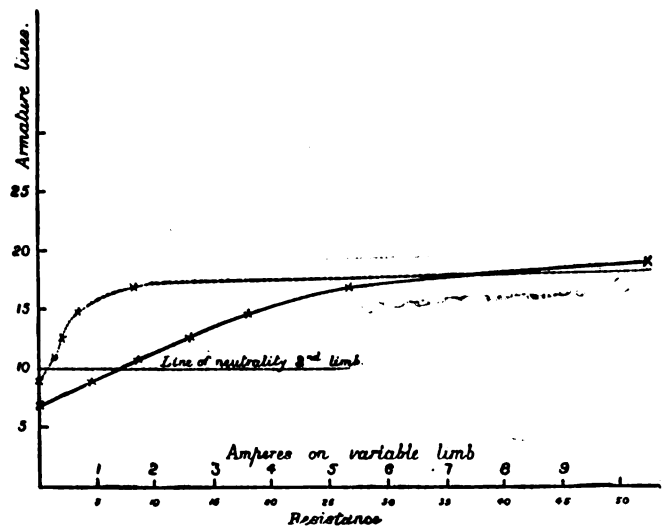

FIG. 4.

A curve is exhibited, showing how the number of (Kapp) lines of force through the armature is raised by altering the current in the coils of the keeper. It would need a keeper of perfect magnetic conductivity to totally short circuit the constantly magnetised limb.

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THE ELECTRICIAN.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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THE EXETER THEATRE.

Under the weight of such an appalling disaster as that which has just visited the city of Exeter, and which has spread consternation throughout the length and breadth of the land, it requires no inconsiderable effort, both moral and mental, to approach the subject from the point of view which it is the duty of this journal to uphold. Nevertheless, we feel that it would be mistimed scrupulosity, and something little short of cowardice, to shrink from pointing the obvious moral of this deplorable accident through fear of seeming to seize the opportunity for what may be called improving the occasion. It was not in this spirit, as our readers will remember, that we commented on the fire at the Opera Comique at Paris; and when a more dreadful calamity has overtaken us at home we are still less disposed to yield to the temptation now. We have never thought it our policy to attack the gas interests on account of the accidents to which their system of lighting is liable; nor in any of our recent remarks on the lighting of places of public amusement have we blamed the management for not adopting a safer system. We frankly recognise the fact that Gas is in possession of the field; and it would be grossly unfair to lay the fault of a catastrophe due to the use of an old-established form of light upon the shoulders of anybody simply because they have not yet seen the necessity for adopting a safer but newer form.

Having said this much, we feel ourselves at liberty to comment freely upon the fatality at Exeter with a sole view to preventing a recurrence elsewhere, so far as any words of ours can tend to that object. The outbreak of the fire was almost identical with that at the Opera Comique, and the consequences differ only in respect to the structure of the building. In both places gas was the illuminant, and at both it was something in the flies that was ignited by the jets. At Exeter, we have it on the authority of the actor who was on the stage at the moment that he saw the gas battens on fire; and his surmise that one of the calico mediums which go over the cages surrounding the gas lights had caught fire is probably the correct one. In a moment after the flies were alight, and the drop scene, which had been promptly lowered to prevent the spread of the fire, was itself in flames, and fell on to the stage. Had it fallen the other way the occupants of stalls and pit might not have escaped as they did. By this time the whole of the upper machinery of the stage was in a blaze, the theatre itself enveloped in smoke, through which it was seen that the flames were spreading to the ceiling and roof. How quickly all this happened may be gathered from the fact that a gentleman in the stalls, who on the first alarm had rushed out into the streets, found when he got there that the flames were issuing from the windows on both sides of the building.

What followed it is needless for us to describe. Suffice it to say that in probably less than a quarter of an hour more than a hundred and fifty people were suffocated, burnt, or trampled to death. In respect to the latter, we may now recall what we said in our leader only six weeks ago. On the gallery staircase, the one sole outlet for the audience in the uppermost part of the house, there was the usual ticket barrier, which, as we urged at the time, ought always to be removed when the play has commenced. There was also, by a grim irony of fate, a patent fire extincteur, over which an eye witness—one of the very few who escaped from the gallery or upper circle, we are not sure which—tells us that he saw several people stumble. A block ensued, and we know the inevitable consequence. In the dress circle the outlet to the *foyer* was handy; and even the stall people were able to stumble up a few stairs, along a passage, and so to the vestibule and street. The extra exits from the pit were, as usual, closed; but happily the pressure of the crowd burst the doors off their hinges, and escaped for the most part with nothing worse than a few bruises. To the upper part of the building the chief fatality was confined; and this being the rule in such cases is an important fact to be borne in mind. It points to the general certainty that fires at theatres will originate on the stage, that the flames spread to the roof, and that the audience in the highest part of the building incur the greatest danger. It is precisely this part of the theatre which is most difficult to provide with adequate exits.

How long the gas remained alight on the gallery staircase we shall perhaps never learn; but probably not many minutes, as there was an explosion of gas on the stage before even the actors could get clear away. What we do know for certain is that gas was burning above the stage in close proximity to materials of the most inflammable kind. We also know that there was nothing uncommon or reprehensible in this arrangement, seeing that it has the sanction of custom to shield it from condemnation. None the less it is a bad custom, and one which ought to be amended without loss of time. It would be too much to expect that every theatrical manager will at once introduce the electric light into his stage fittings in the place of gas; but we do hope that many will do so, for it is impossible to suggest any light other than the electric that would be in all respects safer than gas. The electric light would be absolutely safe. Neither at Paris nor

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at Exeter would there have been any conflagration had the electric light been employed; and of no other light that we are acquainted with can this be said with such perfect confidence—or, indeed, with any confidence at all. Arranged on the plan we described in the article to which we have already referred, and carried out by competent electrical engineers, the building would not only be safeguarded from the ordinary risk of fire but also from the consequences of panic arising from any cause whatever.

Emphasis is given to these reflections by the fact that the theatre at Exeter was a new one, constructed on the latest principles, and apparently provided with appliances and means of safety which are by no means universal even in metropolitan theatres. The outlets for pit, stalls and dress circle were fairly adequate; there was, as we have mentioned, a fire extincteur on the gallery staircase, and, better still, there was on the first tier a hose, which was actually brought into use without any delay; and, lastly, the curtain was lowered just when it ought to be. All these circumstances reflect great credit on the management and on the presence of mind displayed by its subordinates. These and the heroism of the rescuing parties outside deserve the warmest praise, none the less because they were only partially successful. Not quite 200 persons were in the gallery, yet more than half of them it is certain were killed. But for the precautions just mentioned the fatality might have been at least twice as great. There has been the usual talk about panic; but in this case there was no time for steadfastness or reflection. The conflagration was so sudden, so rapid, so overwhelming, that the only chance of life was in instant flight. We ourselves see no conclusive evidence of panic; at all events, all the dreadful consequences which we are now deploring were due to fire; and our last words on this point are that fires of this description need never occur if the prime source of danger were removed—a removal which modern science has now enabled us to accomplish with ease, economy, and certitude. The English papers are full of suggestions for affording means of escape when a fire breaks out; what we urge, and what is being urged unanimously by the Continental press commenting on the Exeter disaster, is that the cause of fire should be got rid of as it has been in most of the great theatres of France, Italy, Austria, and Germany.

CORRESPONDENCE.

RADIATION FROM DULL AND BRIGHT SURFACES AS AFFECTING INCANDESCENT LAMP CARBONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I venture to think that the practical conclusion as to the superior light-giving efficiency of the brilliant looking surface carbon over the dull-looking surface carbon has been tacitly recognised by most lamp makers for the past three or four years.

In the investigations of Mr. Mortimer Evans (Roy. Soc. *Proc.*, Vol. XL., 1886) and by Mr. Bottomley (*The Electrician*, September 2nd, 1887) it is stated that "the same" carbon "filament was treated in such ways as to alter the surface from dull to bright and back again," but they do not state whether either the actual surfaces (upon which radiation is directly dependent) or the surface densities were the same with both filaments; for without either of these measurements their conclusions are not warrantable. In fact, with a pure carbon a brilliant surface is inseparable from a dense surface, and from experiments I have made at different periods during the past two years I find that the light-giving efficiency is dependent in a great degree upon the surface density or degree of porosity.

I find it possible to commence with carbons of the same length and diameter, and to "flash" them in different ways to the same resistance, yet to have their diameter and surface areas quite different; which shows that in one case the surface of the carbon is more dense (less porous) than in the other.

A dull surface carbon prepared as above has a greater porosity, and, therefore, surface area, or has least surface density, and requires a greater amount of energy than the more dense or brilliant surface carbon to bring it to the same measured candle-power or apparent surface temperature.

(I say apparent surface temperature, as I think the points or hills on a dull surface carbon must cut off some of the light radiated from the hollows.)

A brilliant looking surface carbon prepared as above has the least surface area and greatest surface density.

From various experiments I have made, and from those I mention below, I find that the light-giving efficiency and emissivity of a carbon filament is not effected so much by the fact of the surface being dull or bright as it is by the actual density (porosity) of surface.

To prove the relation of light-giving efficiency of a carbon to its surface density, I took three carbons of the same length and diameter and "flashed" them in various ways, so that their final resistances, lengths, and diameters (but not necessarily actual surfaces) were the same.

The "flashing" was so arranged as to obtain carbons of three different structures; *i.e.*, the first carbon had a dense centre or core and a black exterior; the second carbon had an even texture throughout, with a smooth dark grey exterior, but not bright looking; the third carbon had a black porous interior or core, with a brilliant-looking and dense exterior.

The densities were determined by total weight in air and weight at different diameters, and when the carbons were examined under the microscope, the deposit of greatest density had the most brilliant appearance and took place at the highest temperature. These carbons were very long and thick, and were enclosed in glass globes, which were exhausted on the same pump to a high degree.

From the actual tests of these three carbons, it was conclusive that their light-giving efficiency was dependent upon the surface densities, which is a point not observed by Mr. Bottomley, or by Mr. Swinburne, when he mentions experiments he made on the emissivity of dull and bright carbons ("Incandescent Lamp Manufacture," No. XX., *The Electrician*).

Another point I observed from the above experiments was that for a given increase of energy the alteration of hot resistance of a carbon varies with its surface density, and it may be that this fact alone is the chief cause of the differences observed by Mr. Mortimer Evans and by Mr. Bottomley, and would explain why both the black-surfaced (more porous) carbon and platinum required a greater amount of energy than the brilliant surfaced carbon and platinum to bring them to the same measured candle-power.

I should like to be able to prove the effect of a brilliant-looking even surface carbon, and of a brilliant looking nodulous surface carbon, each of the same length, diameter, and resistance, but have not the opportunity at present.

From the observations I have made, I conclude that a pure carbon to possess the greatest light-giving efficiency and duration (other things being equal, vacua, &c.) should have the greatest possible density—that is to say, should be prepared at the highest possible temperatures, and if deposited from a gas or liquid the matter used should require the highest possible heat for its decomposition; also the carbon should have a brilliant and smooth surface.—Yours, &c.,

C. J. ROBERTSON, A.S.T.E.

THE D'HUMY WATER BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read a paragraph in the *Morning Post* of Thursday, August 23rd, 1887, which speaks very highly of Mr. P. D'Humy's primary and secondary batteries. Combined they appear, at very little cost, to give magnificent results; and also by simply turning a switch it is claimed that lights of various

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candle power can be used on the same wire at the same time. It is no novelty to use primary batteries for storing electricity, and I have done so with the E.P.S. Company's small secondary cells, with very fair results. But I have not yet seen the combination perfected, and I should be very glad if some of your readers who have inspected Mr. D'Humy's method would give a practical description of it in your valuable paper.—Yours, &c., CHARLES PENRUDDOCKE.

THE GENERAL THEORY OF DYNAMO MACHINES.*

BY DR. E. HOPKINSON.

Using the term "dynamo" in the widest possible sense, including under it all machines for the conversion of mechanical forms of energy into electro-magnetic, and electro-magnetic into mechanical, there are certain characteristics common and essential to all types of such machines, whether they be known as magneto machines, alternate current machines, or continuous current machines, either compound, shunt, or series wound, and of the drum, ring, or disc type. It is therefore possible, up to a certain point, to construct a theory of dynamo machines which is perfectly general in its application. The object of the present paper is to trace briefly the outlines of such a theory, and to indicate how the consideration of specific types of machines can be developed therefrom, and in what direction research is required to elucidate some points still obscure. A dynamo consists essentially of two closed circuits or "tubes," in both of which there is a displacement of the nature of a flux dependent upon the relative motion of the two circuits. We may call one of these the "magnetic circuit," and the other the "electric circuit." Either or both of these may be in motion; but as we are concerned only with the relative motion of the two, we may for convenience (as, in fact, is usually the case) regard the magnetic circuit as fixed, or displaced only by the reaction of the electric circuit upon it, and consider the latter only as moving under external forces, whether electric or mechanical. The flux along the magnetic circuit is called the "magnetic induction," which is a vector or directed quantity, requiring for its definition reference to co-ordinate axes. It is subject to the fundamental condition known as the "solenoid condition," or "equation of continuity," which may be expressed in words "that the flux across all sections of the tube is the same," or otherwise "the induction through any surface bounded by a closed curve depends only on the form and position of the closed curve, and not on that of the surface itself." The flux along the second circuit is called the "electric current," and is also a vector quantity, subject to the solenoid condition. Neither circuit is necessarily bound by the limits of the machine, and both may be and generally are sub-divided. Both these fluxes are produced by corresponding forces, called respectively "magnetic force" and electromotive force," which likewise are vector quantities, but are defined by reference to a line instead of by an area, as is the case with the fluxes. (Maxwell, "Treatise on Electricity and Magnetism," Vol. I., page 10.) The solenoidal condition for magnetic induction is a direct deduction for Coulomb's original experiments, verified by all subsequent observations in magnetism. We now require to know the relation between each force and its corresponding flux. Let us first inquire into the relation between the magnetic induction (B) and the magnetic force (H). Such a relation may be expressed by the general equation

$$B = f^{-1}(H).$$

The form of the function depends upon the medium in which the tube is drawn, and also upon the physical conditions of the medium. For air and all other gases, and generally for all substances classed as "non-magnetic," it is a linear function possessing one coefficient or constant only. For such substances the equation may be written

$$B = \mu H.$$

Since the numerical definition of H is at our disposal, we may so define H that μ is unity for all the substances above referred to, and write $B = H$.

For iron, and generally for all magnetic substances, H is not a linear function of B, and its expression will involve several constants depending upon the medium, and such physical conditions as temperature and strain, and its previous history. The determination of the form of the function for iron in particular has been the subject of a great number of experiments, but no general expression has yet been discovered, and it has usually been found most convenient to record the experimental results in the form of a curve referred to rectangular axes, in which the ordinates represent magnetic induction and the abscissæ magnetic force. Such curves have been fully investigated for iron of various composition, and under varying physical conditions, among others particularly by G. Wiedemann ("Die Lehre vom Galvanismus," Vol. II., p. 340, and *sequor*), Rowland (*Phil. Mag.*, Aug., 1873), Carl Barus and Vincent Strouhal (*Bulletin* of the United States Geological Survey, No. 14, 1885), J. Hopkinson (*Phil. Trans.* of R.S., Part II., 1885), J. A. Ewing (*Phil. Trans.* R.S., Part II., 1885, and Part II., 1886, and *Proc.* of R.S., Vol. XLII., p. 200, 1887). By reference to these memoirs it is now possible to construct the curve with fair accuracy for iron of any known composition. For convenience we may express the curve by the equation

$$B = \mu H;$$

μ is then the tangent of the angle which the tangent to the curve makes with the axis of x. It has received various names: by Sir William Thomson, "permeability" (Reprint of "Papers on Electricity and Magnetism," Vol. II., page 54); by Maxwell, "coefficient of magnetic induction" ("Treatise on Electricity and Magnetism," Vol. II., page 54); and again, "magnetic inductive capacity" (Vol. II., page 243).

Secondly, we require to know the relation between the E.M.F. and current. This is well known to be expressed by a linear relation, known as Ohm's law, involving one constant coefficient only, universally designated the "resistance."

$$E = R C,$$

E being the E.M.F. and C the current. As far as all experimental evidence goes, R and the reciprocal of μ possess the same two characteristics, viz., that for any given substances in any defined physical condition they are proportional to the length of tube considered, and inversely proportional to its cross section; μ may therefore without impropriety be called the reciprocal of the "magnetic resistance," but as expressing this analogy only. It must be distinctly remembered that for magnetic substances there is no such relation as Ohm's law.

Having now defined the relation between the fluxes and their corresponding forces, it remains to consider the relation between the fluxes themselves, dependent upon the relative motion of their circuits. This may be expressed in various ways, all of which are the expressions of Faraday's well known law; (*i.*) The line integral of the E.M.F round the electric circuit is the rate of decrease of the surface integral of magnetic induction through any area bounded by the circuit; or (*ii.*) the time integral of the total E.M.F. round the electric circuit together with the surface integral of the induction through the circuit is a constant quantity. Again, since the surface integral of any vector over any surface which satisfies the solenoidal condition can be expressed by a line integral round any closed curve bounding the surface, a new vector may be introduced called the "vector potential" of magnetic induction, which is such that its line integral round any circuit is equal to the surface integral of induction over any surface bounded by the circuit. Also the time integral of the E.M.F. in any circuit is the electro-magnetic momentum. Hence Faraday's law may be expressed (*iii.*) the electro-magnetic momentum of a circuit is the line integral of the vector potential round the circuit (Maxwell, Vol. II., pages 28 and 234).

Excluding for the moment the consideration of magneto machines with permanent magnets, and of machines in which iron plays no part whatever, we may more particularly consider that class of dynamos in which the magnetic field is produced by the use of iron excited by a current, and we then require to know the relation between the current and the induction in the magnetic field produced by the current. Faraday showed that the magnetic field in the neighbourhood of an electric current is the same as that of a magnetic shell bounded by the circuit of the current, and has therefore a similar mag-

* Paper read before the British Association Meeting at Manchester, September, 1887.

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negtic potential. This is expressed by saying (*iv.*) that the line integral of magnetic force round any closed curve is zero, provided the closed curve does not surround the electric current, and if the current passes through the closed curve, then the line integral is proportional to the number of times it passes through, and is equal to $4\pi n c$, where c is the current and n the number of times it passes through the closed curve.

If we take the magnetic units as fundamental, the propositions (*i.*) and (*iv.*) define the units of E.M.F. and current. On the other hand, if we start with the arbitrary units of E.M.F. and current, based on quite other considerations, the propositions define the units of magnetic induction and magnetic force in terms of these.

We have now the materials for a complete investigation of a dynamo of any given configuration and constructed of iron, whose magnetic qualities are known. It is required to determine the E.M.F. and current in the electric circuit, as its configuration relative to the magnetic circuit is changed by the application of external forces, and as the magnetic forces in the magnetic circuit are changed either by external electro-magnetic forces or electro-magnetic forces derived from the current circulating in the electric circuit. The magnetic circuit consists in general of four parts: (*i.*) The magnet limb, which is surrounded by coils of wire, through which the exciting current is passed, which may be derived either from external sources or may be part of the electric circuit of the machine. (*ii.*) The field pieces, or the extended polar extensions of the magnet limb, embracing the armature. (*iii.*) The air space being the necessary interval between the iron of the pole-pieces and the iron of the armature, or in cases where the armature contains no iron, the interval between the opposed pole pieces. This interval may be an entirely free air space or partially occupied with other non-magnetic matter, according to the particular type of machine. (*iv.*) The armature, or that part of the machine carrying that portion of the electric circuit which is subject to displacement under external forces. There may be other subsidiary portions of the machine—*e.g.*, the magnet limb may be divided into one or more portions connected by yokes, but as these may be treated in exactly the same way as the pole-pieces they do not require special consideration. Again, the magnet limb may be divided so as to form several magnetic circuits, each of which may be considered independently. In alternate current such sub-division is universal, and is not infrequent in continuous current machines.

The magnetic circuit is thus subject to magnetic forces due to the current in the armature and the current round the magnet limb. We must therefore, in the general case, take these as the two independent variables, which we may denote by C and c. Now, it may be assumed with sufficient accuracy that in the magnet limb the boundaries of the tube of magnetic induction are coincident with the boundaries of the iron, and the cross section of the tube the same as the cross section of the iron. Outside the limb a portion of the lines of force will complete a magnetic circuit through external space, and will not enter the pole-pieces. The extent of this leakage or induction, from which no useful effect is obtained, depends upon the configuration of the machine and the degree of saturation of the iron, and could be calculated therefrom; but as it can be experimentally determined for any machine with great ease, it is unnecessary to consider it further, and we may regard the total induction in the magnet limb as greater than the induction in the pole pieces in a constant ratio, which we will denote by ν_1. It is usual to construct the pole-pieces of large section compared with the magnet limb, and hence the section of the pole-pieces may again be taken as the section of the tube of induction; but as the lines of force leave the pole-pieces to cross the air space, we cannot ascribe any boundary to the tube, but in every machine a portion only can pass through the armature, and part must pass from one pole-piece to the other by lines external to the armature. Moreover, the relation between the two parts will not be a constant one, unless the magnetic forces in the armature are constant, which can never be the case. It is, therefore, necessary to consider the tube of induction, which crosses the air space and enters the armature, as a variable portion of the whole tube, the variation depending upon the magnetic forces in the armature. We may denote the ratio of the induction through the pole-pieces to the induction through the armature by ν_2. Knowing now the components of the magnet circuit, we can determine the magnetic forces in the several parts, and hence obtain the induction in the tube. Let A_1 be the cross section of the magnet limb, l_1 its length; A_2 the cross section of the pole pieces, l_2 the mean length of the tube therein; A_3 the cross section of the air space, comprising all the space through which the lines entering the armature pass, l_3 its length; A_4 the cross section of the iron of the armature (if it contains iron), and l_4 the mean length of the tube of force therein. Then the line integral of magnetic force taken round the circuit is

$$\frac{1}{\mu_1} l_1 \frac{\nu_1\nu_2 I}{A_1} + \frac{1}{\mu_2} l_2 \frac{\nu_2 I}{A_2} + \left(\frac{1}{\mu_3}\frac{l_3}{A_3} + \frac{1}{\mu_4}\frac{l_4}{A_4}\right) I,$$

the μ's being the coefficients of magnetic induction for the several portions of the circuit. For air the coefficient is unity, hence $\mu_3 = 1$. I is the total induction in the armature, which is assumed to be uniformly distributed over the tube. The integration has extended along the tube only which passes through the armature, and hence the forces along the portions of the whole tube which pass outside the machine do not appear. Now the magnetic circuit is cut by the current in the magnet coils and the current in the armature. Let n_1 be the number of times it is cut by the former, n_2 by the latter. Then

$$\frac{1}{\mu_1} l_1 \frac{\nu_1\nu_2 I}{A_1} + \frac{1}{\mu_2} l_2 \frac{\nu_2 I}{A_2} + \left(\frac{l_3}{A_3} + \frac{1}{\mu_4}\frac{l_4}{A_4}\right) I = 4\pi (n_1 c + n_2 C).$$

It must be noted that the direction in which the circuit is cut by c and C is in both cases taken to be positive. Referring to three rectangular axes and measuring the induction along the axis of z, the current round the magnets, along the axis of x, and that in the armature along the axis of y, the above equation may be written

$$l_1 f_1\left(\frac{\nu_1\nu_2 z}{A_1}\right) + l_2 f_2\left(\frac{\nu_2 z}{A_2}\right) + l_3 \frac{z}{A_3} + l_4 f_4\left(\frac{z}{A_4}\right) = 4\pi (n_1 x + n_2 y).$$

This represents a surface the ordinate at any point of which is the induction through the armature. Such a surface was first described by Dr. John Hopkinson (Lecture before the Inst. of C.E., April, 1883), and is called the "characteristic surface." It must be remembered ν_1 is a constant coefficient, or may be taken as such with sufficient accuracy, but ν_2 is not constant. It is unnecessary to consider further its general form, as it may better be determined in connection with the particular type of machine under consideration. f_1 f_2 f_4 would be the same functions if the quality of the iron were the same in the several portions of the machine.

Having obtained a general expression for the induction in the armature, the electromotive force in the electric circuit, when displaced, can be deduced by Faraday's law.

Consider now the application to alternate current machines. Such machines are usually multipolar. In machines of the disc type the number of poles is even, and the armature is divided into sections corresponding to the number of poles, and revolves uniformly between them. The tube through any one pair of opposed poles and back through another need only be considered, and the total effect of the machine obtained therefrom by summation. Suppose the iron of both magnets and armature so arranged that no currents are induced therein. There is then only one electric circuit to deal with. The whole current in one section of the armature cuts the magnetic tube passing through the section as many times as there are convolutions. Let m be the number of convolutions. The current x round the magnets is usually derived from independent sources, and maintained constant. For each such constant value the characteristic surface becomes a curve giving the relation between the induction through the armature and the current in it. The areas A_1, A_2, and A_4, and the lengths l_1, l_2, l_3, and l_4 are constant, but the area A_3 is a periodic function of the time, and can be expressed by a series of cosines, the coefficients of the series being determined by Fourier's theorem from the dimensions of the machine. The general consideration of the form of ν_2 has been worked out by Dr. J. Hopkinson (*Proc.* R.S., 1887), and need not be referred to further. The induction is a function of the time, but as an example consider

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its value at that epoch when the cores of the armature are exactly opposed to the pole pieces.

$$\frac{l_1\nu_1\nu_2 I}{\mu_1 A_1}+\frac{l_2\nu_2 I}{\mu_2 A_2}+\left(\frac{l_3}{A_3}+\frac{l_4}{\mu_4 A_4}\right)I=4\pi n_1 c-4\pi m C.$$

Since the coefficients are all determinate by measurement or experiment, I is obtained in terms of c and C. Assume that, instead of continuous rotation of the armature, the action of the machine is such that each core of the armature is moved periodically in an infinitely short time from between one pair of poles to the next. Let T be the periodic time, E the electromotive force, then

$$E=m\frac{2\pi}{T}I.$$

Hence E is determined in terms of c and C. E is here the maximum E.M.F. The E.M.F. as measured by a Cardew voltmeter or equivalent instrument will be $\frac{1}{\sqrt{2}}$ of the maximum.

If the equation of the characteristic be differentiated with regard to the time, we shall obtain an equation of the form

$$A\dot{y}+By=\text{periodic function of } t,$$

when B is constant and A is a periodic function of t, but usually assumed to be constant, and called the "self induction" of the machine. In the case of an alternate current machine there are usually other magnetic forces acting upon the electric circuit external to the generating machine. For instance, the electric circuit may contain a transformer, or a second machine inserted as a motor, or an arc lamp in which there is a constant E.M.F. changing sign with the current. It is not, then, sufficient to consider the magnetic tube within the machine only, but the effect of all other tubes which are cut by the circuit must be included, and the characteristic surface of the whole system obtained by summation. These cases have been worked out, taking A as by Dr. J. Hopkinson (*Journal* of Tel. Engineers, 1884).

Now consider the application to continuous current machines. With the exception of certain types of dynamos, like that of Professor Forbes or the cylinder dynamo of Dr. Werner Siemens, in general no current continuous in direction can be obtained by continuous rotation of any part of the electric circuit, unless arrangement is made for reversing the current at a certain stage of each revolution. If the rotating part contained one section only, the current, though continuous in direction, would oscillate from zero to its maximum. To avoid this the electric circuit is divided into a number of sections, arranged symmetrically on the armature, the current in one or two of which only is reversed at a time. If the number of sections be even and equal to $2m$, one half will be in series, and one half the total current will pass through each half, except at the instant of commutation. At such time two sections are short circuited, and form complete circuits in which the current will be determined by the induction through them at the time; and the number of sections in series will be $\overline{m-1}$. If the number of sections be odd and equal to $\overline{2m+1}$, one section only will be commuted at a time, and at that instant there will be m sections in series. At other times there will be $\overline{m+1}$ sections in series on one side and m on the other, and consequently there will be a superposed current flowing through the armature only, due to the inequality in the number of sections in series in the two halves. In one revolution of the armature the tube of induction through it will be cut four times by each section, and if the plane of commutation is symmetrical with regard to the tube of induction the current in one half the sections will cut it in the opposite direction to that in the other half. In this case, $n_2=0$. But any displacement of the plane of commutation from the symmetrical position will cause the current in a greater number of sections to cut the tube in one direction than in the other. Let λ be the angular advance of the plane of commutation, and m the number of sections in the armature; then $n_2=\frac{\lambda m}{\pi}$. The value of λ may be fixed for any given machine, or varied at pleasure, or may be determined to avoid sparking at the time of commutation of a section. The general discussion of the value of λ to effect this has not yet been attempted. For the present λ must be regarded as independent. The general equation of the characteristic surface becomes for a continuous current machine,

$$l_1 f_1\left(\frac{\nu_1\nu_2 z}{A_1}\right)+l_2 f_2\left(\frac{\nu_2 z}{A_2}\right)+l_3\frac{z}{A_3}+l_4 f_4\left(\frac{z}{A_4}\right)=4\pi n_1 x-4\lambda m y,$$

λ being reckoned positive when the displacement is in the direction of rotation.

If no current passes through the armature $y=0$ and ν_2 may be taken as constant and determined by experiment. The equation may then be written

$$l_1 f_1\left(\frac{\nu_1\nu_2 z}{A_1}\right)+l_2 f_2\left(\frac{\nu_2 z}{A_2}\right)+l_3\frac{z}{A_3}+l_4 f_4\left(\frac{z}{A_4}\right)=4\pi n_1 x$$

which is the equation to the characterictic curve of a shunt-wound or separately-excited machine, and determines the induction for all values of the exciting current. Having determined the characteristic when $y=0$, the characteristic surface can be determined therefrom by considering the form of ν_2. (*See* J. and E. Hopkinson, *Trans.* of R.S., Part I., 1886, p. 334.)

It has been assumed that the sections of the armature are the only conductors in the field, or that the armature is so constructed that no currents circulate in the iron. This in the best machines is only partially attained. The effect of such currents on the characteristic surface is the same as increasing the current in the armature. If the lead is negative the induction is increased both by the current in the sections of the armature and in the iron; but such a negative lead must give rise to destructive sparking, as the sections will be commuted in a strong field.

ON THE MAGNETISATION OF IRON IN STRONG FIELDS.*

BY PROF. J. A. EWING, B.SC., F.R.S., AND WILLIAM LOW.

In March of the present year we communicated to the Royal Society (*Proceedings*, Vol. XLII., p. 200) the results of experiments on this subject, in which the magnetism of a narrow neck or isthmus of iron placed between the pole-pieces of a large electro-magnet was examined, by suddenly drawing out the piece, or turning it end for end so that the direction of its magnetisation was reversed. The piece examined was in the form of a bobbin with a short central neck, turned to a small diameter and with large spreading conical ends, which were in contact with the pole-pieces and provided an easy path for the lines of induction to converge to the central neck. The metal of the neck was in this way subjected to a much greater magnetic force than it would be practicable to produce by the direct action of a magnetising solenoid. The induction in the iron was measured ballistically by means of a coil of fine wire, in a single layer, round the iron neck. The magnetic force in the air space closely contiguous to the neck was also measured by means of a second or outer induction coil of a slightly greater diameter than the inner one. This determination of the field allowed a correction to be applied for the air space enclosed by the inner coil, and it also gave what was probably a close approximation to the value of the magnetic force within the metal itself.

The object of the present note is to describe shortly the results of further experiments of the same kind, the details of which may be reserved for subsequent publication.

In the former experiments an electro-magnet with pole-pieces 5½cm. square was used. The conical ends of the bobbins tested brought the central neck down to a diameter of 0·65cm. in one form of sample and 0·923cm. in another form. With this we succeeded in forcing the induction 𝔅 in Low-moor and Swedish wrought iron up to values lying between

* Abstract of paper read before the British Association Meeting at Manchester, Sept., 1887.

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32,000 and 33,000 C.-G.-S. units, the strength of the magnetic field in the air close to the neck being then about 11,000 C.-G.-S. units.

Large as those values were, they have been greatly exceeded in the present series of experiments. In the former paper we pointed out that the magnetic induction of the iron examined showed no sign of approaching a maximum, and that the value to which it might be forced by the "isthmus" method depended on the scale of the experiments. Through the kindness of Prof. Tait in allowing the large electro-magnet of the Edinburgh University Laboratory to be brought to Dundee, we have now been able to subject iron to much higher magnetising forces, and to secure a much greater concentration of the lines of induction. The Edinburgh magnet is one of exceptional power. Its limbs, which are vertical, are about 60 cms. long, and the cores are 10·7 cms. in diameter. Rectangular blocks of soft wrought iron 9·6cms. square serve for pole-pieces. To allow the old bobbins to be effectively used we added a pair of conical intermediate pieces of soft iron, which virtually formed an extension of the conical ends of the bobbin. Between these the bobbin was placed, the form generally used being that described in the previous paper as sample A. The neck of this sample had originally a diameter of 0·923cm., and consequently a section of 0·669 square cm., or about $\frac{1}{140}$ that of the pole-pieces. As in the former experiments, the highest values of magnetism have been reached with Lowmoor iron, and nearly as high values with Swedish iron.

The same Lowmoor bobbin that had been formerly used (sample A) had its magnetism measured by withdrawing it from the field, while the magnet with all its numerous coils in series was excited by a current which ranged up to 40 amperes. At the highest value the induction $\mathfrak{B}$ in the neck was 38,000 C.-G.-S., and the outside field, close to the neck, was 18,900 C.-G.-S. A Swedish sample of the same shape gave an induction of 37,620 with a field of about the same force.

To push the induction to still higher values the Lowmoor sample was then turned down in the central neck until the diameter was reduced to 0·397cm. This made its section only $\frac{1}{740}$ of the section of the pole-pieces. Careful determinations, several times repeated, then gave for the highest induction the enormous value 43,500 C.-G.-S., the outside field being 25,620 C.-G.-S. Here, as in the other figures already given, the induction stated is that which is found after the air space enclosed by the inner coil is allowed for, and after a suitable allowance is made for the residual magnetism of the piece. The residual induction is only about 500 C.-G.-S. units.

The ratio $\frac{\mathfrak{B}}{\text{outside field}}$ in this extreme case is 1·7, and the quantity $\frac{\mathfrak{B} - \text{outside field}}{4\pi}$, which would be the intensity of magnetism $\mathfrak{T}$ if the magnetic force within the metal were identical in value with the outside field, is 1,420. In the former experiments this quantity had values which decreased from 1,680 to 1,620, while the induction increased from about 25,000 to 32,000. Here, with an induction of 43,500, it has fallen off to a much more marked extent. We cannot yet speak with any certainty as to the degree of approximation of this quantity to the intensity of magnetism $\mathfrak{T}$; unless, however, the mean magnetic force within the neck is much less than the force at the surface, the results show that $\mathfrak{T}$ is becoming less as the induction is being forced to these extreme values—in other words, that the iron is tending towards diamagnetism in the manner Weber's theory leads us to expect. The question is one of the greatest interest, and we are now endeavouring to obtain a better knowledge of the magnetic force within the metal by examining the variation of the force at short distances from the surface of the neck.

A final effort was made to force the induction in Lowmoor iron to higher values, by turning the central neck down still further, until its section was less than $\frac{1}{1500}$ of the section of the pole-pieces, and annealing the bobbin carefully before magnetising it. The value of $\mathfrak{B}$ then reached was 45,350 C.-G.-S. units, which is the greatest induction recorded in any of our experiments.

With cast-iron the induction has been forced to 31,270 C.-G.-S., by applying a magnetic force of 16,900.

DISCUSSION.

Lord RAYLEIGH said he had had no experience himself on this interesting subject of the induction of very high forces. The interest of it was apparent to all, but until they knew pretty definitely what did happen at the end of the curve, it was obvious that speculations as to the nature of magnetism were very premature. He hoped that Prof. Rowland would give the section the benefit of his views on the subject.

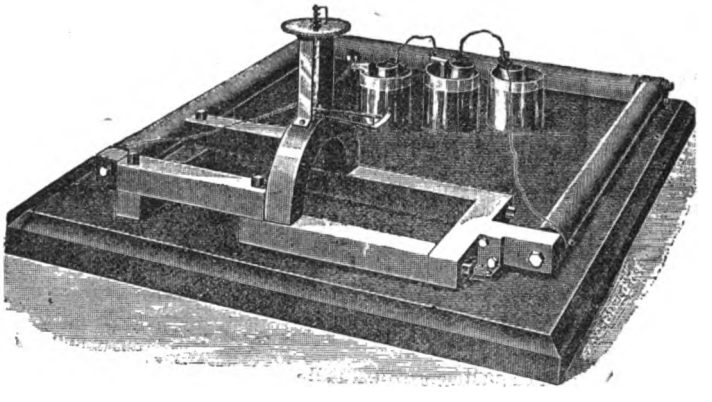
Prof. ROWLAND (of Baltimore) said that when he first made experiments on the lines suggested by the paper, he was, like Prof. Ewing, troubled with a little curvature at the end, and as he had experimented with rings of iron he attributed the circumstance to the iron not being homogeneous, and he turned off the off-side ring, which had been forged originally, and then more of it, with the result that he found that to some extent the curvature disappeared. Therefore, he ascribed the curvature to that cause. But his experiments were not sufficient to establish whether there was a maximum for the magnetic induction, or for the intensity of the magnetisation. He should say from those experiments that it was a decided maximum for the intensity of magnetisation. When one subtracted the intensity of the field from the magnetic induction, the results were very similar, and, as Prof. Ewing remarked, they then decreased in value, due possibly to an error in the experiments. He thought that they showed a decided maximum of magnetism, at a higher value than he gave, but the maximum was for the intensity of the magnetisation, and never for the magnetic induction. In that case he did not see any reason why the curvature should not be due to the original cause which he gave, which was want of homogeneity of iron. There were some particles in the original iron which did not attain their full power, but required a very strong field to magnetise them, and one could see very readily if one had a mixture of steel and soft iron that it would give a curve of this nature. He was not at all convinced himself but that the curving was something very similar to that he had recently given.

Prof. EWING observed that he ought to have said, with regard to the question whether that quantity had really passed the maximum, that it would require the field to be inaccurate to the extent of at least 12 per cent. to make the quantity really constant instead of apparently a descending one, as now appeared—that was to say, the field in the last set of experiments would have required to have been 22,000 instead of 25,000, in order to make the quantity constant. He did not know why want of homogeneity could be a possible cause of the curve taking the direction they now knew it to take. It seemed difficult to understand why the want of homogeneity in the iron should make it possible to get an induction of 45,000 C.-G.-S. units into it if a piece of pure iron stopped at 25,000 or so.

ON A MAGNETIC BRIDGE OR BALANCE FOR MEASURING MAGNETIC CONDUCTIVITY.*

BY THOMAS A. EDISON.

Perhaps no electric measuring instrument has proved more useful in practice, especially if we consider the various forms which it has assumed, than the device contrived by Christie and commonly known as Wheatstone's bridge. It was with a belief that a similar instrument could be constructed which should perform the same service for magnetic measurements that the experiments were made the results of which I have the honour now to present to the section.



The Wheatstone bridge is based upon the fact that if two points of different electric potentials are united by two conducting paths the fall of potential along these paths is absolutely the same provided that these paths are absolutely alike electrically. Consequently if two points equidistant from the place of higher potential be connected together no current will flow through the connecting wire. So by analogy, if two points be maintained at a constant difference of magnetic potential the fall of potential from one to the other through two or more paths will be absolutely uniform in all, provided these paths be magnetically identical. Hence, at any two points equi-distant from a given terminal, the magnetic potential is the same, and these points could be without differential action upon a magnetic pole.

The magnetic bridge may be constructed in the form of a rhomb, the

* Read before the American Association for the Advancement of Science, New York, August, 1887.

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typical form of the Wheatstone bridge. For this purpose the four sides are made of the purest Norway iron, as soft as possible, and thoroughly annealed. To the acute angles of the rhomb are connected the poles of a long U-shaped electro-magnet, whose function is to develop the desired magnetic potential difference at these points. Connected to the two obtuse angles, and projecting inward, are two bars of Norway iron, similar in section to those forming the sides. Their inner ends, which are hollowed out, approach to within about half an inch of each other. Between these ends a stirrup is suspended by means of a silk fibre, which stirrup carries a short needle consisting of a thin tube of hardened steel well magnetised. To the stirrup is attached either a pointer moving over a graduated arc, or better, a mirror by means of which the deflection can be read in the usual way with a lampstand and scale.

In the instrument now in use in my laboratory (see accompanying illustrations) the magnetic bridge is in the form of a rectangle, the ends or poles of the electro-magnet being connected to the middle of the short sides, while the bars which pass inward to the needle are joined to the middle of the longer sides. The four halves of these longer sides constitute the sides of the bridge. The two at one end of the rectangle are fixed, the two at the other end are movable. The two bars which pass inward to the needle are curved so as to form a semicircle standing above the plane of the rectangle. The needle itself is similar in construction to that above described, but is suspended by a wire attached to a torsion head.

It will be readily seen that when the electro-magnet is charged, a constant difference of magnetic potential is maintained at the two ends of the rectangle, so that if the four bars constituting the sides of the bridge are magnetically identical, there will be no difference of magnetic potential between the ends of the bars which pass to the needle, and hence there will be no deflection. But if one of the moveable bars be loosened, the needle is at once deflected, and in a direction depending upon the side the bar occupies. If the bar is entirely removed the deflection is a maximum, of course. And if it be replaced by another bar differing in cross section, in quality of iron, or in any other way which affects the magnetic conductivity through the bridge, the deflection shows at once the amount of difference between that bar and the original one taken as a standard. The instrument is extraordinarily delicate, and the principal difficulties encountered in using it have arisen in the attempt to preserve this delicacy while at the same time the range of the apparatus is maintained.

The magnetic bridge was devised for the purpose of testing readily the quality of the iron purchased for the construction of dynamos. Very great variations are observed in irons supposed, commercially, to be of the same quality. Consequently the potential difference developed by a dynamo having field cores of such iron can never be exactly calculated. But by comparing the iron which is to be thus used in the magnetic bridge, its exact value for dynamo purposes may be determined, and the constants of the generator thus accurately calculated in advance.

But this bridge, it would seem, will be equally useful for testing iron and steel for other purposes. By its means not only may the character and quality of the metal be ascertained in terms of any desired standard, but flaws in the interior of a bar such as a car axle may be discovered at once.

Constructed with sufficient care and attention to details, the magnetic bridge may without doubt be made a most valuable instrument of precision for the furtherance of scientific research. The theory of its action is extremely simple, and it is the exact counterpart of an ordinary Wheatstone bridge constructed for measuring low resistance and immersed in salt water, since now whatever is true electrically of the one is true magnetically of the other. Not only may the laws of magnetic conductivity be investigated by means of this balance for all paramagnetic and diamagnetic bodies, but the variation of this conductivity under the action of various physical agencies, such as heat, pressure, strain, &c., may be determined.

EDISON'S PYRO-MAGNETIC DYNAMO.

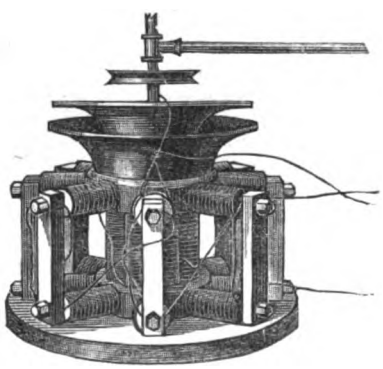

Fig. 1.

In our issue of last week we gave a full description of Edison's Pyro-Magnetic Dynamo, and we have since obtained drawings, from which the adjoining illustrations have been engraved. Figure 1 shows the upper part of the generator, which is placed as it stands upon the top of a furnace or stove. The hot air ascends through the upright iron tubes seen in the centre, and which are covered with asbestos and wound outside with the armature wires. The rectangular upright bars and horizontal coils represent the field-magnets. The rotating part is better seen in Figure 2, in which the field-magnets are removed. The rotating screen, which cuts off

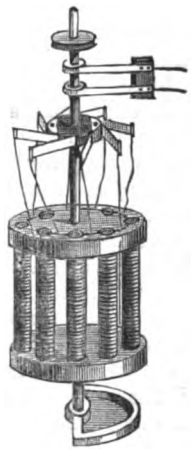

Fig. 2.

the hot air, is seen below, and above is the commutator and collecting brushes.

THE MIX AND GENEST MICROPHONE.

After repeated trials made by the German Postal Department with the microphones constructed by Messrs. Mix and Genest, these apparatus have been introduced in the place of the telephones and Bell-Blake microphones hitherto used in the telephone service. At present there are about 5,000 in use. This fact alone is a sufficient reason for giving our readers a description of this instrument.

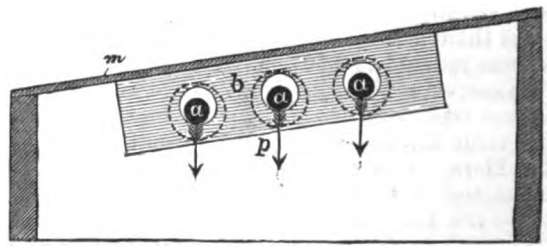

Fig. 1.

In microphones constructed after the system represented in Fig. 1 a kind of rattling noise is frequently occasioned, which borne along with the sound of the human voice causes an audible disturbance in the telephone. The chief causes of these disturbances may be ascribed to the fact that the carbon rollers in their journals *a* rest loose in the flutings of the beam *b*, which is fastened to the sound-plate *m*. Owing to the shocks given to the entire apparatus and independent of the oscillations of the sound-plate, they are set in motion and roll to and fro in their bearings.

In microphones in which the sound plates are arranged vertically, as shown in Fig. 2, these disturbances assume such a character that there is no possibility of understanding the speaker, for in this case the horizontally directed oscillations of the sound-plate *m* cause themselves a backward and forward motion on the part of the carbon rollers without increasing or decreasing at the same time the lying on pressure of the roller journals, and by doing so bring the places of contact one on the other, and thus occasion a conducting resistance of greater or less force. The circumstance serves as an explanation of the reason why the sound-plates in Ader's microphones are not arranged vertically, although this way of arranging them offers many advantages over a horizontal or slightly inclined arrangement of the sound-plates. Speaking is more convenient in the vertical arrangement, and moreover the plates can be fitted on to instruments better in this way.

These drawbacks are avoided in the apparatus by Messrs. Mix and Genest. A sort of braking contrivance operates on the carbon rollers in such a way as to prevent their journals from lying on the lower points in the flutings of the beams. Thus, for instance, if in a microphone with a horizontal sound plate, as illustrated in Fig. 3, the carbon rollers are pressed upwards by outward force, it is evident that only a very trifling rolling and disturbing motion can occur, and only small pieces of carbon can be knocked off, which would act injuriously as a secondary contact. The same may be said of the journals of microphones with vertical sound plates, as represented

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in Fig. 4, when the carbon rollers are pressed in the direction of the arrow *p*—that is to say, against the sound-plate. In this case the journals *a* are fixed in the flutings of the beams *b* in a direction given them by the power and gravity operating on them, which is clearly represented in the accompanying design, Fig. 4.

In all such cases the regulating contrivance applied to brake the carbon rollers in their motion has the result that only the oscillations transmitted from the sound-plate on to the contacts come in operation, whereas disturbing mechanical shocks resulting from any outward influences occasion no, or at least very insignificant, vibrations, which are not perceptible in the telephone. The separate contacts thus form a firm system with the sound-plate, so that the

FIG. 2.

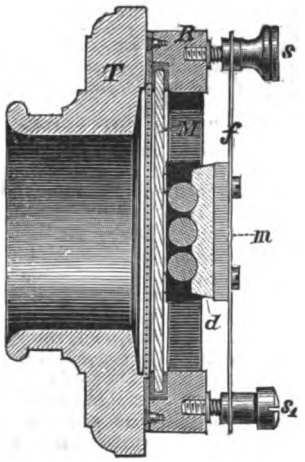

FIG. 6.

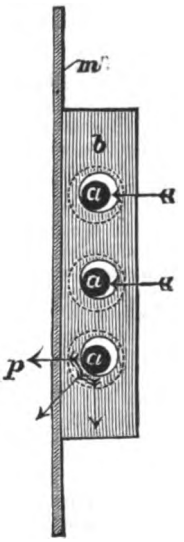

FIG. 4.

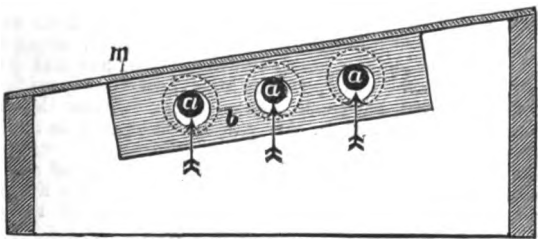

FIG. 3.

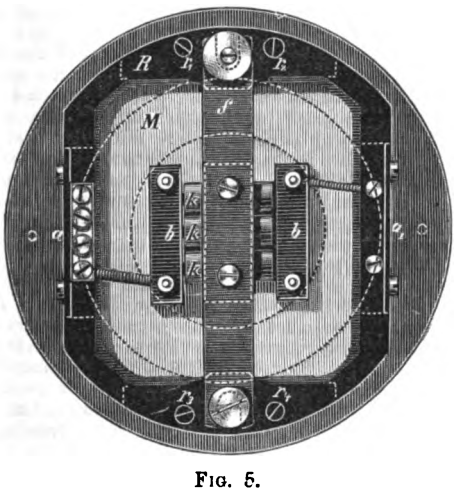

FIG. 5.

former are influenced in their motions and effects solely and alone by the shocks and oscillations which operate direct on these sound-plates. The rolling motion of the carbon rollers is thus removed in this way, and the distinctness of the words spoken is greatly augmented. This has been proved most effectually by the trials that have been instituted with this apparatus.

The above Figures 4 and 5 show the microphone in side view and cross section.

A metal ring, R (see Fig. 5), is fastened by means of the 4 screws r_1 r_2 r_3 r_4 on to a wooden mouth-piece; in a recess of the above ring is the diaphragm M, which is provided on its outer edge with an indiarubber band and is held in position by the two clamps *a* and a_1. The diaphragm is cut out of finely fibred firwood and is well lacquered to preserve it against dampness. On it there are two carbon beams *b*, and in the perforations of the latter are the journals of the carbon rollers *k*. The alterations in contact take place in the touching points. The cross piece *f* that runs straight across the carbon rollers serves as a braking contrivance, which is regulated as may be necessary by the large projecting screws.

Fig. 6 shows the apparatus in cross section. T is the mouthpiece, R the metal ring, M the diaphragm, *f* the braking cross-piece. On the latter is a metal block fastened by means of two screws. On this metal block is a soft elastic strip, *d*, of felt or similar material. The letters *s* and s_1 indicate the regulating screws for the braking contrivance.

One simple regulation of the microphone suffices for the installation, and there is no danger of its getting out of order, as is too often the case with Blake's microphone.

THE BRITISH ASSOCIATION MEETING AT MANCHESTER, 1887.

THE PRESIDENT'S ADDRESS.

(Concluded from page 365.)

In spite of these predictions, and in spite of Wöhler's memorable discovery in 1828 of the artificial production of ures, which did in reality break down for ever the barrier of essential chemical difference between the products of the inanimate and of the animate world, still, even up to a much later date, contrary opinions were held, and the synthesis of urea was looked upon as the exception which proves the rule. So it came to pass that for many years the artificial production of any of the more complicated organic substances was believed to be impossible. Now the belief in a special vital force has disappeared like the *ignis fatuus*, and no longer lures us in the wrong direction. We know now that the same laws regulate the formation of chemical compounds in both animate and inanimate nature, and the chemist only asks for a knowledge of the constitution of any definite chemical compound found in the organic world in order to be able to promise to prepare it artificially.

But the progress of synthetic organic chemistry, which has of late been so rapid, was made in the early days of the half-century only by feeble steps and slow. Seventeen long years elapsed between Wöhler's discovery and the real synthesis. This was accomplished by Kolbe, who in 1845 prepared acetic acid from its elements. But then a splendid harvest of results gathered in by chemists of all nations quickly followed, a harvest so rich and so varied that we are apt to be overpowered by its wealth, and amidst so much that is alluring and striking we may well find it difficult to choose the most appropriate examples for illustrating the power and the extent of modern chemical synthesis.

Next, as a contrast to our picture, let us for a moment glance back again to the state of things fifty years ago, and then notice the chief steps by which we have arrived at our present position. In 1837 organic chemistry possessed no scientific basis, and therefore no classification of a character worthy of the name. Writing to Berzelius in that year, Wöhler describes the condition of organic chemistry as one enough to drive a man mad. "It seems to me," says he, "like the tropical forest primæval, full of the strangest growths, an endless and pathless thicket in which a man may well dread to wander." Still clearances had already been made in this wilderness of facts. Berzelius in 1832 welcomed the results of Liebig and Wöhler's research on benzoic acid as the dawn of a new era; and such it really was, inasmuch as it introduced a novel and fruitful idea, namely, the possibility of a group of atoms acting like an element by pointing out the existence of organic radicles. This theory was strengthened and confirmed by Bunsen's classical researches on the cacodyl compounds, in which he showed that a common group of elements which acts exactly as a metal can exist in the free state, and this was followed soon afterwards by isolation of the so-called alcohol radicles by Frankland and Kolbe. It is, however, to Schorlemmer that we owe our knowledge of the true constitution of these bodies, a matter which proved to be of vital importance for the further development of science.

Turning our glance in another direction we find that Dumas, in 1834, by his law of substitution threw light upon a whole series of singular and unexplained phenomena by showing that an exchange can take place between the constituent atoms in a molecule. Laurent, indeed, went farther, and assumed that a chlorine atom, for example, took up the position vacated by an atom of hydrogen and played the part of its displaced rival, so that the chemical and physical properties of the substitution-product were thought to remain substantially the same as those of the original body. A singular story is connected with this discovery. At a *soirée* in the Tuileries in the time of Charles X. the guests were almost suffocated by acrid vapours which were evidently emitted by the burning wax candles, and the great chemist Dumas was called in to examine into the cause of the annoyance. He found that the wax of which the candles were made had been bleached by chlorine, that a replacement of some of the hydrogen atoms of the wax by chlorine had occurred, and that the suffocating vapours consisted of hydrochloric acid given off during the combustion. The wax was as white and odourless as before, and the fact of the substitution of chlorine for hydrogen could only be recognised when the candles were destroyed by burning. This incident induced Dumas to investigate more closely this class of phenomena, and the results of this investigation are embodied in his law of substitution. So far, indeed, did the interest of the French school of chemists lead them that

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some assumed that not only the hydrogen but also the carbon of organic bodies could be replaced by substitution. Against this idea Liebig protested, and in a satirical vein he informs the chemical public, writing from Paris under the *nom de plume* of S. Windler, that he has succeed in substituting not only the hydrogen but the oxygen and carbon in cotton cloth by chlorine, and he adds that the London shops are now selling nightcaps and other articles of apparel made entirely of chlorine, goods which meet with much favour, especially for hospital use!

But the debt which chemistry, both inorganic and organic, thus owes to Dumas' law of substitution is serious enough, for it proved to be the germ of Williamson's classical researches on etherefication, as well as of those of Wurtz and Hofmann on the compound ammonias, investigations which lie at the base of the structure of modern chemistry. Its influence has been, however, still more far-reaching, inasmuch as upon it depends in great measure the astounding progress made in the wide field of organic synthesis.

It may here be permitted to me to sketch in rough outline the principles upon which all organic syntheses have been effected. We have already seen that as soon as the chemical structure of a body has been ascertained, its artificial preparation may be certainly anticipated, so that the first step to be taken is the study of the structure of the naturally occurring substance which it is desired to prepare artificially by resolving it into simpler constituents, the constitution of which is already known. In this way, for example, Hofmann discovered that the alkaloid coneine, the poisonous principle of hemlock, may be decomposed into a simpler substance well known to chemists under the name of pyridine. This fact having been established by Hofmann, and the grouping of the atoms approximately determined, it was then necessary to reverse the process, and, starting with pyridine, to build up a compound of the required constitution and properties, a result recently achieved by Ladenburg in a series of brilliant researches. The well-known synthesis of the colouring matter of madder by Graebe and Liebermann, preceded by the important researches of Schunck, and that of indigo by Baeyer, are other striking examples in which this method has been successfully followed.

Not only has this intimate acquaintance with the changes which occur within the molecules of organic compounds been utilised, as we have seen, in the synthesis of naturally occurring substances, but it has also led to the discovery of many new ones. Of these perhaps the most remarkable instance is the production of an artificial sweetening agent termed saccharin, 250 times sweeter than sugar, prepared by a complicated series of reactions from coal-tar. Nor must we imagine that these discoveries are of scientific interest only, for they have given rise to the industry of the coal-tar colours, the value of which is measured by millions sterling annually, an industry which Englishmen may be proud to remember was founded by our countryman Perkin.

Another interesting application of synthetic chemistry to the needs of everyday life is the discovery of a series of valuable febrifuges, amongst which I may mention antipyrin as the most useful. An important aspect in connection with the study of these bodies is the physiological value which has been found to attach to the introduction of certain organic radicles, so that an indication is given of the possibility of preparing a compound which will possess certain desired physiological properties, or even to foretell the kind of action which such bodies may exert on the animal economy.

But it is not only the physiological properties of chemical compounds which stand in intimate relation with their constitution, for we find that this is the case with all their physical properties. It is true that at the beginning of our period any such relation was almost unsuspected, whilst at the present time the number of instances in which this connection has been ascertained is almost infinite. Amongst these perhaps the most striking is the relationship which has been pointed out between the optical properties and chemical composition. This was in the first place recognised by Pasteur in his classical researches on racemic and tartaric acids in 1848; but the first to indicate a quantitative relationship and a connection between chemical structure and optical properties was Gladstone in 1863. Great instrumental precision has been brought to bear on this question, and consequently most important practical applications have resulted. I need only refer to the well-known accurate methods now in everyday use for the determination of sugar by the polariscope, equally valuable to the physician and to the manufacturer.

But now the question may well be put, Is any limit set to this synthetic power of the chemist? Although the danger of dogmatising as to the progress of science has already been shown in too many instances, yet one cannot help feeling that the barrier which exists between the organised and unorganised worlds is one which the chemist at present sees no chance of breaking down.

It is true that there are those who profess to foresee that the day will arrive when the chemist, by a succession of constructive efforts, may pass beyond albumen, and gather the elements of lifeless matter into a living structure. Whatever may be said regarding this from other standpoints, the chemist can only say that at present no such problem lies within his province. Protoplasm, with which the simplest manifestations of life are associated, is not a compound, but a structure built up of compounds. The chemist may successfully synthesise any of its component molecules, but he has no more reason to look forward to the synthetic production of the structure than to imagine that the synthesis of gallic acid leads to the artificial production of gall-nuts.

Although there is thus no prospect of our effecting a synthesis of organised material, yet the progress made in our knowledge of the chemistry of life during the last fifty years has been very great, and so much so, indeed, that the sciences of physiological and of pathological chemistry may be said to have entirely arisen within this period.

In the introductory portion of this address I have already referred to the relations supposed to exist fifty years ago between vital phenomena and those of the inorganic world. Let me now briefly trace a few of the more important steps which have marked the progress of this branch of science during this period. Certainly no portion of our science is of greater interest, nor, I may add, of greater complexity than that which, bearing on the vital functions both of plants and of animals, endeavours to unravel the tangled skein of the chemistry of life, and to explain the principles according to which our bodies live and move and have their being. If, therefore, in the less complicated problems with which other portions of our science has to deal, we find ourselves, as we have seen, often far from possessing satisfactory solutions, we cannot be surprised to learn that with regard to the chemistry of the living body—whether vegetable or animal—in health or disease we are still farther from a complete knowledge of phenomena, even those of fundamental importance.

It is of interest here to recall the fact that nearly fifty years ago Liebig presented to the Chemical Section of this Association a communication in which, for the first time, an attempt was made to explain the phenomena of life on chemical and physical lines, for in this paper he admits the applicability of the great principle of the conservation of energy to the functions of animals, pointing out that the animal cannot generate more heat than is produced by the combustion of the carbon and hydrogen of his food.

"The source of animal heat," says Liebig, "has previously been ascribed to nervous action, or to the contraction of the muscles, or even to the mechanical motions of the body, as if these motions could exist without an expenditure of force [equal to that] consumed in producing them." Again, he compares the living body to a laboratory furnace in which a complicated series of changes occur in the fuel, but in which the end-products are carbonic acid and water, the amount of heat evolved being dependent, not upon the intermediate, but upon the final products. Liebig asked himself the question, does every kind of food go to the production of heat; or can we distinguish, on the one hand, between the kind of food which goes to create warmth, and, on the other, that by the oxidation of which the motions and mechanical energy of the body are kept up? He thought that he was able to do this, and he divided food into two categories; the starchy or carbohydrate food is that, said he, which by its combustion provides the warmth necessary for the existence and life of the body. The albuminous or nitrogenous constituents of our food, the flesh meat, the gluten, the casein out of which our muscles are built up, are not available for the purposes of creating warmth, but it is by the waste of those muscles that the mechanical energy, the activity, the motions of the animal are supplied. We see, said Liebig, that the Esquimaux feeds on fat and tallow, and this burning in his body keeps out the cold. The Gaucho, riding on the pampas, lives entirely on dried meat, and the rowing man and pugilist, trained on beefsteaks and porter, require little food to keep up the temperature of their bodies, but much to enable them to meet the demand for fresh muscular tissue, and for this purpose they need to live on the strongly nitrogenous diet.

Thus far Liebig. Now let us turn to the present state of our knowledge. The question of the source of muscular power is one of the greatest interest, for, as Frankland observes, it is the corner-stone of the physiological edifice and the key to the nutrition of animals.

Let us examine by the light of modern science the truth of Liebig's view—even now not uncommonly held—as to the functions of the two kinds of food, and as to the cause of muscular exercise being the oxidation of the muscular tissue. Soon after the promulgation of these views, J. R. Mayer, whose name as the first expositor of the idea of the conservation of energy is so well known, warmly attacked them, throwing out the hypothesis that all muscular action is due to the combustion of food and not to the destruction of muscle, proving his case by showing that if the muscles of the heart be destroyed in doing mechanical work the heart would be burnt up in eight days! What does modern research say to this question? Can it be brought to the crucial test of experiment? It can; but how? Well, in the first place we can ascertain the work done by a man or any other animal: we can measure this work in terms of our mechanical standard, in kilogramme metres or foot-pounds. We can next determine what is the destruction of nitrogeneous tissue at rest and under exercise by the amount of nitrogenous material thrown off by the body. And here we must remember that these tissues are never completely burnt, so that free nitrogen is never eliminated. If, now, we know the heat value of the burnt muscle, it is easy to convert this into its mechanical equivalent, and thus measure the energy generated. What is the result? Is the weight of muscle destroyed by ascending the Faulhorn or by working on the treadmill sufficient to produce on combustion heat enough when transformed into mechanical exercise to lift the body up to the summit of the Faulhorn or to do the work on the treadmill? Careful experiment has shown that this is so far from being the case that the actual energy developed is twice as great as that which could possibly be produced by the oxidation of the nitrogenous constituents eliminated from the body during twenty-four hours. That is to say, taking the amount of nitrogenous substance cast off from the body, not only whilst the work was being done but during twenty-four hours, the mechanical effect capable of being produced by the muscular tissue from which this cast-off material is derived would only raise the body halfway up the Faulhorn, or enable the prisoner to work half his time on the treadmill.

Hence it is clear that Liebig's proposition is not true. The nitrogeneous constituents of the food do doubtless go to repair the waste of muscle, which, like every other portion of the body, needs renewal, whilst the function of the non-nitrogenous food is not only to supply the animal heat, but also to furnish, by its oxidation, the muscular energy of the body.

We thus come to the conclusion that it is the potential energy of the food which furnishes the actual energy of the body, expressed in terms either of heat or of mechanical work.

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But there is one other factor which comes into play in this question of mechanical energy, and must be taken into account; and this factor we are as yet unable to estimate in our usual terms. It concerns the action of the mind upon the body, and, although incapable of exact expression, exerts none the less an important influence on the physics and chemistry of the body, so that a connection undoubtedly exists between intellectual activity or mental work and bodily nutrition. In proof that there is a marked difference between voluntary and involuntary work, we need only compare the mechanical action of the heart, which never causes fatigue, with that of the voluntary muscles, which become fatigued by continued exertion. So, too, we know well that an amount of drill which is fatiguing to the recruit is not felt by the old soldier, who goes through the evolutions automatically. What is the expenditure of mechanical energy which accompanies mental effort is a question which science is probably far removed from answering. But that the body experiences exhaustion as the result of mental activity is a well-recognised fact. Indeed, whilst the second law of thermodynamics teaches that in none of the mechanical contrivances for the conversion of heat into actual energy can such a conversion be complete, it is perhaps possible, as Helmholtz has suggested, that such a complete conversion may take place in the subtle mechanism of the animal organism.

The phenomena of vegetation, no less than those of the animal world, have, however, during the last fifty years been placed by the chemist on an entirely new basis. Although before the publication of Liebig's celebrated report on chemistry and its application to agriculture, presented to the British Association in 1840, much had been done, many fundamental facts had been established, still Liebig's report marks an era in the progress of this branch of our science. He not only gathered up in a masterly fashion the results of previous workers, but put forward his own original views with a boldness and frequently with a sagacity which gave a vast stimulus and interest to the questions at issue. As a proof of this I may remind you of the attack which he made on, and the complete victory which he gained over, the humus theory. Although Saussure and others had already done much to destroy the basis of this theory, yet the fact remained that vegetable physiologists up to 1840 continued to hold to the opinion that humus, or decayed vegetable matter, was the only source of the carbon of vegetation. Liebig, giving due consideration to the labours of Saussure, came to the conclusion that it was absolutely impossible that the carbon deposited as vegetable tissue over a given area, as for instance over an area of forest land, could be derived from humus, which is itself the result of the decay of vegetable matter. He asserted that the whole of the carbon of vegetation is obtained from the atmospheric carbonic acid, which, though only present in the small relative proportion of 4 parts in 10,000 of air, is contained in such absolutely large quantity that if all the vegetation on the earth's surface were burnt, the proportion of carbonic acid which would thus be thrown into the air would not be sufficient to double the present amount.

That this conclusion of Liebig's is correct needed experimental proof, but such proof could only be given by long-continued and laborious experiment, and this serves to show that chemical research is not now confined to laboratory experiments lasting perhaps a few minutes, but that it has invaded the domain of agriculture as well as of physiology, and reckons the periods of her observations in the field not by minutes but by years It is to our English agricultural chemists, Lawes and Gilbert, that we owe the complete experimental proof required. And it is true that this experiment was a long and tedious one, for it has taken forty-four years to give the definite reply. At Rothamsted a plot was set apart for the growth of wheat. For forty-four successive years that field has grown wheat without addition of any carbonised manure; so that the only possible source from which the plant could obtain the carbon for its growth is the atmospheric carbonic acid. Now, the quantity of carbon which on an average was removed in the form of wheat and straw from a plot manured only with mineral matter was 1,000 pounds, whilst on another plot, for which a nitrogenous manure was employed, 1,500 pounds more carbon was annually removed; or 2,500 pounds of carbon are removed by this crop annually without the addition of any carbonaceous manure. So that Liebig's prevision has received a complete experimental verification.

May I, without wearying you with experimental details, refer for a moment to Liebig's views as to the assimilation of nitrogen by plants—a much more complicated and difficult question than the one we have just considered—and compare these with the most modern results of agricultural chemistry? We find that in this case his views have not been substantiated. He imagined that the whole of the nitrogen required by the plant was derived from atmospheric ammonia; whereas Lawes and Gilbert have shown by experiments of a similar nature to those just described, and extending over a nearly equal length of time, that this source is wholly insufficient to account for the nitrogen removed in the crop, and have come to the conclusion that the nitrogen must have been obtained either from a store of nitrogenous material in the soil or by absorption of free nitrogen from the air. These two apparently contradictory alternatives may perhaps be reconciled by the recent observations of Warrington and of Berthelot, which have thrown light upon the changes which the so-called nitrogenous capital of the soil undergoes, as well as upon its chemical nature, for the latter has shown that under certain conditions the soil has the power of absorbing the nitrogen of the air, forming compounds which can subsequently be assimilated by the plant.

Touching us as human beings even still more closely than the foregoing, is the influence which chemistry has exerted on the science of pathology, and in no direction has greater progress been made than in the study of micro-organisms in relation to health and disease. In the complicated chemical changes to which we give the names of fermentation and putrefaction, the views of Liebig, according to which these phenomena are of a purely chemical character, have given way under the searching investigations of Pasteur, who established the fundamental principle that these processes are inseparably connected with the life of certain low forms of organisms. Thus was founded the science of bacteriology which in Lister's hands has yielded such splendid results in the treatment of surgical cases; and in those of Klebs, Koch, and others has been the means of detecting the cause of many diseases both in man and animals; the latest, and not the least important of which is the remarkable series of successful researches by Pasteur into the nature and mode of cure of that most dreadful of maladies—hydrophobia. And here I may be allowed to refer with satisfaction to the results of the labours on this subject of a committee, the formation of which I had the honour of moving for in the House of Commons. These results confirm in every respect Pasteur's assertions, and prove beyond a doubt that the adoption of his method has prevented the occurrence of hydrophobia in a large proportion of persons bitten by rabid animals, who, if they had not been subjected to this treatment, would have died of that disease. The value of his discovery is, however, greater than can be estimated by its present utility, for it shows that it may be possible to avert other diseases besides hydrophobia by the adoption of a somewhat similar method of investigation and of treatment. This, though the last, is certainly not the least of the debts which humanity owes to the great French experimentalist. Here it might seem as if we had outstepped the boundaries of chemistry, and have to do with phenomena purely vital. But recent research indicates that this is not the case, and points to the conclusion that the microscopist must again give way to the chemist, and that it is by chemical rather than by biological investigation that the causes of diseases will be discovered, and the power of removing them obtained. For we learn that the symptoms of infective diseases are no more due to the microbes which constitute the infection than alcoholic intoxication is produced by the yeast-cell, but that these symptoms are due to the presence of definite chemical compounds, the result of the life of these microscopic organisms. So it is to the action of these poisonous substances formed during the life of the organism, rather than to that of the organism itself, that the special characteristics of the disease are to be traced; for it has been shown that the disease can be communicated by such poisons in entire absence of living organisms.

If I have thus far dwelt on the progress made in certain branches of pure science it is not because I undervalue the other methods by which the advancement of science is accomplished, viz., that of the application and of the diffusion of a knowledge of nature, but rather because the British Association has always held, and wisely held, that original investigation lies at the root of all application, so that to foster its growth and encourage its development has for more than fifty years been our chief aim and wish.

Had time permitted I should have wished to have illustrated this dependence of industrial success upon original investigation, and to have pointed out the prodigious strides which chemical industry in this country has made during the fifty years of Her Majesty's reign. As it is, I must be content to remind you how much our modern life, both in its artistic and useful aspects, owes to chemistry, and, therefore, how essential a knowledge of the principles of the science is to all who have the industrial progress of the country at heart.

This leads me to refer to what has been accomplished in this country of ours towards the diffusion of scientific knowledge amongst the people during the Victorian era. It is true that the English people do not possess, as yet, that appreciation of the value of science so characteristic of some other nations. Up to very recent years our educational system, handed down to us from the middle ages, has systematically ignored science, and we are only just beginning, thanks in a great degree to the prevision of the late Prince Consort, to give it a place, and that but an unimportant one, in our primary and secondary schools or in our universities. The country is, however, now awakening to the necessity of placing its house in order in this respect, and is beginning to see that if she is to maintain her commercial and industrial supremacy the education of her people from top to bottom must be carried out on new lines. The question as to how this can be most safely and surely accomplished is one of transcendent national importance, and the statesman who solves this educational problem will earn the gratitude of generations yet to come.

In conclusion, may I be allowed to welcome the unprecedentedly large number of foreign men of science who have on this occasion honoured the British Association by their presence, and to express the hope that this meeting may be the commencement of an international scientific organisation, the only means nowadays existing, to use the words of one of the most distinguished of our guests, of establishing that fraternity among nations from which politics appear to remove us further and further by absorbing human powers and human work, and directing them to purposes of destruction. It would indeed be well if Great Britain, which has hitherto taken the lead in so many things that are great and good, should now direct her attention to the furthering of international organisations of a scientific nature. A more appropriate occasion than the present meeting could perhaps hardly be found for the inauguration of such a movement.

But whether this hope be realised or not, we all unite in that one great object, the search after truth for its own sake, and we all, therefore, may join in re-echoing the words of Lessing: "The worth of man lies not in the truth which he possesses, or believes that he possesses, but in the honest endeavour which he puts forth to secure that truth; for not by the possession of truth but by the search after it are the faculties of man enlarged, and in this alone consists his ever-growing perfection. Possession fosters content, indolence, and pride. If God should hold in His right hand all truth, and in His left hand the ever-active desire to seek truth, though with the condition of perpetual error, I would humbly ask for the contents of the left hand, saying, 'Father, give me this; pure truth is only for Thee.'"

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COMPANIES' MEETINGS & REPORTS.

Manchester and District Edison Electric Light Company.

The annual meeting of this Company was held at the Memorial Hall, Albert-square, Manchester, on Monday last, under the presidency of Mr. V. K. Armitage, when the following report of the Directors was taken as read :—

"The balance sheet, though showing only a slight improvement on the previous year's work of the Company, confirms the opinion expressed by the Directors at the last annual meeting, that the prospect of work to be done in the future is more favourable. Applications for estimates of the cost of installing the electric light are more numerous, and the interest taken by the public is more practical than in former years, indicating that this system of lighting is coming more in favour the better it is understood. Since the last meeting of the Company the Directors have terminated the central installation in Mount-street, and, consequently, the heavy expenses in connection with that establishment, the lease of which expires in December, are practically at an end. The lease of the Company's show room and offices also expires this year, and in seeking fresh premises the Directors are actuated by a desire to reduce the present expenses of the show room, which, as an advertising medium, is not any longer necessary. The reduction in the expenses which the above changes will bring about will better enable the Company to meet the great competition they have to encounter, and this, coupled with an anticipated increase of business, will no doubt place it in the power of the Directors to make a much more satisfactory report next year. The value of the incandescent lamp patents held in the Manchester district by this Company has been considerably enhanced by the judgment given in favour of the Edison and Swan United Company having been sustained in the Court of Appeal. Two of the Directors, Sir Joseph C. Lee and J. C. Waterhouse, Esq , retire in accordance with the Company's Articles of Association ; they are, however, eligible, and offer themselves for re-election."

The CHAIRMAN, in moving the adoption of the report, expressed himself very hopeful with regard to the future of the Company, which had, he said, done work of an admirable quality during the past year. A striking proof of that was to be seen at the Jubilee Exhibition at Old Trafford, for there had not been a single word of complaint with regard to the work which the Company had done there. Another reason for congratulation was found in the fact that the value of the incandescent lamp patents held in the Manchester district by the Company had been considerably enhanced in consequence of the judgment given in favour of the Edison and Swan United Company having been sustained in the Court of Appeal.

The report having been adopted, the retiring Directors, Sir Joseph C. Lee and Mr. J. S. Waterhouse, were re-elected.

It was subsequently decided to alter the name of the Company to the "Manchester Edison-Swan Company (Limited)."

After a vote of thanks to the Chairman and Directors the meeting terminated.

NEW COMPANIES REGISTERED.

LONDON ELECTRIC SUPPLY CORPORATION (LIMITED).—A company having this title has just been registered with a capital of £1,000,000, in £5 shares, for the purpose of acting as undertakers for the supply of electricity for lighting and other purposes within the City of London and the area included in the London postal district. The first directors are : The Hon. Reginald T. D. Brougham, the Right Hon. the Earl of Crawford, Francis Ince, Sir Coutts Lindsay, Bart., Joseph Pyke, Arthur Henry Wade, and the Right Hon. the Lord Wantage, V.C., K.C.B. The directors are to be entitled in each year to fees of £2,000 ; and, in addition, one-tenth of the surplus profits of the year, after providing the reserve fund and paying the shareholders a dividend of 5 per cent. But provision is made that the total remuneration shall not exceed £500 per annum in respect to each £1,000,000 of capital from time to time issued.

UNIVERSAL ELECTRIC COMPANY (LIMITED).—Registered by Elmslie, Forsyth and Elmslie, 27, Leadenhall-street, E.C., with a capital of £50,000 in £5 shares. Object, to carry on in any part of the world the business of an electric light company in all its branches, and in particular to lay down, establish, fix and carry out all necessary cables, wires, lines, accumulators, lamps, and such other works as may be needful or convenient to generate, accumulate, distribute and supply electricity, and to light cities, towns, streets, docks, markets, theatres, buildings, and any other places, both public and private, and to form electric exchanges or centres. The first subscribers are :—

	Shares.
C. Capito, M.E., 63, Queen Victoria-street, E.C.	1
M. P. Hard, electrical engineer, 63, Queen Victoria-street	1
E. Damiquet, 24, Rue Baudin, Paris	1
A. de Cavaillon, engineer, 24, Rue Baudin, Paris	1
Thos. Fardon, M.E., Luton	1
J. R. Marsh, accountant, Luton	1
W. N. de Mattos, merchant, 27, Leadenhall-street	1

The remuneration of the directors shall be £200 per annum, which sum shall be divided among them in such proportions and manner as the directors shall determine. The managing directors are Charles Capito, Eugène Damiquet and Anthony de Cavaillon, and they shall be entitled to hold that office for a period of ten years certain, during good conduct, and they shall receive the remuneration of £100 per annum so long as they hold such office ; but when and so soon as 5,000 lamps are in operation by the company, such salary shall be increased to £300 per annum, and, in addition, they shall be entitled to one-half of the surplus net profits of the company after a dividend of not less than £15 per cent. per annum on the capital has been declared and paid to the shareholders, the right to such share of profits to be continued for a period of fifteen years.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 2nd inst. amounted to £3,543.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of August was 2,983, estimated to produce £2,250, against 2,848 messages, producing £2,163 in the corresponding month of last year. The traffic receipts for the month of May, estimated to produce £3,050, realised £3,061.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of August amounted to £1,614, against £1,379 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—This company's traffic receipts for the month of August amounted to £43,609, against £44,091 for the corresponding period of 1886, a decrease of £482.

EASTERN EXTENSION AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August amounted to £36,274, and to £34,687 in the corresponding period of 1886, showing an increase of £1,587.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August were £23,600 ; from 1st January to 31st August, they amounted to £174,120 ; while for the corresponding months of 1886 and 1835, they amounted to £169,960 and £192,040 respectively.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended September 2nd, amounted to £2,820, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending 31st August amounted to £4,525.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 31st August are £2,010, as compared with £2,003 in the corresponding period of 1886. The May receipts, estimated at £5,651, realised £5,737.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 7.		Business Done Week Ending Sept. 7. Highest.		Lowest.	
Anglo-American	36½,	37⅛	.....	37⅛	.....	36½
Do. Preferred	59½,	60½	.....	60½	.....	58½
Do. Deferred	13½,	14½	.....	15	.....	13⅜
Brazilian Submarine	11½,	11⅝	.....	11⅝	.....	—
Cuba	11⅜,	12½	.....	—	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅜,	3½	.....	—	.....	—
Do. Preference	7½,	8½	.....	—	.....	—
Direct United States Cable	8⅜,	9½	.....	8⅞	.....	8 11-16
Eastern Telegraph	10⅜,	11½	.....	11½	.....	10⅜
Do. 6 per Cent. Preference	14,	14½	.....	14½	.....	14⅛
Do. 5 per Cent. Debentures, 1899	106,	109	.....	107⅛	.....	107½
Eastern Extension	11⅞,	12	.....	12	.....	11⅞
German Union	10⅛,	11	.....	10½	.....	—
Globe Telegraph and Trust	5⅜,	5⅝	.....	5 9-16	.....	5 7-16
Do. Preference	13½,	13⅝	.....	13⅜	.....	13
Great Northern	13½,	14	.....	13 15-16	.....	13⅞
Indo-European	85,	87	.....	—	.....	—
Reuter's	7½,	8	.....	—	.....	—
Submarine	170,	180	.....	176	.....	—
West India and Panama	⅝,	¾	.....	—	.....	—
Do. 1st Preference	9,	9½	.....	—	.....	—
Western Brazilian	7⅞,	8	.....	7⅞	.....	—
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	101,	104	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	.....	—	.....	—
Oriental	5-16	7-16	.....	—	.....	—
United Telephone	12½,	12⅝	.....	12½	.....	12⅛
United River Plate	4½,	5	.....	—	.....	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	—	.....	—
Do. (fully paid)	3,	4	.....	—	.....	—
Swan	1½,	1¾	.....	—	.....	—
Maxim Weston	⅛,	¼	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	----	37	----	36⅝
India Rubber, Gutta Percha, and Telegraph Works	22,	23	----	23⅛	----	22⅞

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NOTES.

GENOA.—A very extensive project for lighting this town by electricity is now on foot. It is probable that the Zipernowski-Déri system will be employed.

TRAIN LIGHTING.—It is announced that the Canada Atlantic Railway Company will shortly introduce incandescent electric lighting in their passenger cars.

PERSONAL.—We are informed that Mr. Percy R. Allen has resigned the position of manager to the Woodhouse and Rawson Electric Manufacturing Company.

SUBMARINE CABLES.—The cable of the Paris-New York Telegraph Company, which was interrupted in the early part of August, has now been repaired.—The cable between Trinidad and Demerara is interrupted.

TYNEMOUTH.—At a special meeting of the Tynemouth Town Council, held this week, it was decided to accept the tender of the Gülcher Electric Light Company for providing electric light for the market place, amounting to £912.

ROYAL COLLEGE OF SCIENCE FOR IRELAND.—We would call the attention of our readers to the information which will be found in our advertisement columns concerning the curriculum of this important college. The session commences on Monday, October 3rd.

ATLANTIC CABLE REPAIRS.—We are informed that the 1869 cable of the Anglo-American Telegraph Company, which was broken in deep water on 9th November last, at a distance of 600 miles from St. Pierre, Miquelon, was repaired on the 12th inst., and is now working well.

TEMPORARY ARC LIGHTING AT BIRMINGHAM.—Messrs. Fowler, Lancaster, and Co., of Birmingham, are running a temporary installation of five Pilsen arc lamps in the streets of that town, in order to enable the contractor for the cable tramway to complete the work in time.

THE NEW YORK ELECTRICAL EXHIBITION.—The Exhibition to be held at New York under the auspices of the New York Electrical Society will be opened on the 28th of this month. Applications have been made for seven hundred horse-power to run 2,500 incandescent lamps, 200 arc lamps, and 300 motors.

POST OFFICE TELEGRAPHS REVENUE.—The revenue returns for the half year ended Sept. 10, 1887, show that the total receipts into the Exchequer from the telegraph service between 1st April and 10th September was £905,000. Compared with the corresponding period last year there has been an increase of £65,000.

LYONS.—The gas company of this town has entered into a contract to supply electric light to the municipal theatres on the same scale and at the same price as gas. In return for this the company has obtained the right to lay underground cables through the streets. A central lighting station will be immediately established.

PERSONAL.—We are informed that, owing to pressure of business in other directions, Mr. Dowsing has found it necessary to retire from the membership of the firm previously known as Messrs. Thompson, Dowsing and Rew. The business will be conducted as heretofore by the remaining partners, under the style of "Thompson and Rew."

TELEPHONIC CONTRACTS OPEN.—On the 26th instant the telegraph department in Madrid will adjudicate a contract for the establishment and working of the telephonic lines in Vigo, and on the 27th instant for the telephonic lines in Granada. Particulars can be obtained from the director of the telegraph department, No. 8, Calle Claudio Coello, Madrid.

TELEGRAPH STORES REQUIRED.—The Great Western Railway Company are open to receive tenders for the supply of telegraph material, including instruments, poles, and wire. Samples may be seen on and after the 19th inst. at the office of the storekeeper, Paddington Station. Specifications and forms of tender may be obtained at the office of the storekeeper at Paddington or Swindon Stations. Tenders will be received up to October 3rd.

DANISH TELEGRAPHS.—The report of the Danish Telegraph Department for the year 1885 has just made its appearance. The country contains—or did contain in 1885—347 telegraph offices, 6 new stations having been opened during the year. The number of messages amounted to 714,286, which represents 36 per 100 inhabitants. There are four public telephone offices. Communication is still maintained in some parts of Denmark by semaphore signals.

ELECTRIC TRACTION BY ACCUMULATORS.—The *Bulletin Technologique* for September (issued by the Société des Anciens Eléves des Ecoles Naturales d'Arts et Métiers) contains a remarkably interesting paper by M. Bandsept on electric traction by accumulators, as exemplified on the Brussels tramways. We regret that in the present crowded state of our columns, we do not see any immediate chance of reproducing the article, which is of considerable length. Those, however, who are specially interested in the subject should not fail to read M. Bandsept's paper.

TAMPERING WITH RACING TELEGRAMS.—At the Bow-street Police Court Henry Wilkes, a clerk in the Central Telegraph Office, was charged with having tampered with a telegram by altering the order of the words. The telegram contained the names of the horses starting for a certain race, and it was alleged that the prisoner had detained the message until the result of the race was received, and had then made the alteration described, it being implied that in this way information was conveyed to the addressee enabling him to bet upon a known result. The prisoner was remanded for a week.

ELECTRIC LIGHTING IN MINES.—In the House of Commons on Monday last Mr. Matthews, answering Mr. Kelly, said he was aware the electric light was very little used in mines, but he looked forward to that light as being likely to form the best safeguard against explosions. He had seen various lamps which made him sanguine that some lamp which would satisfy practical requirements would shortly be invented, if the problem had not been solved already. He should use all the means in his power to induce the colliery proprietors to use this class of lamp, and he was glad to hear that the miners' delegates would use their influence in the same direction.

ELECTRICAL TREATMENT OF SILVER ORE.—At Douglass Mill, Dayton, Nevada, a method of treating silver ore by the aid of electricity has been brought into operation by Dr. J. H. Doe. The description given is by no means clear, but it appears that a current is passed through the ore while being treated with mercury in the crushing mill, with the result that an immense saving of mercury is effected. At Douglass Mill 135 tons of ore are worked per day, and it is stated that after two months' trial the economy effected is at the rate of £12,000 per annum. It is for this reason that we allude to the subject with only the present obscure account before us. Several new machines are being erected at neighbouring works.

INSULATED WIRES ON THE BROOKLYN BRIDGE.—A very large number of telegraph, telephone, and electric light wires

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pass over the Brooklyn Suspension Bridge, and some trouble has arisen from their insulation. At first the wires were laid in iron pipes, but the average American insulation is not good enough for this simple method. Wooden cleating was next tried, but the damp salt sea air saturated the wood, and serious trouble again arose. Next the wires were supported on glass insulators, extending some distance away from the iron structure. This has answered for the smaller wires, but difficulty was still found with the electric light cables which supplied the arcs upon the bridge itself. Finally, these wires were covered at all joints and connections with a special insulating paint supplied by the Standard Paint Company, and this appears to have proved a remedy for the evil.

THE LIGHTING OF THE CITY OF LONDON.—The negotiation between the Commissioners of Sewers and the Anglo-American Brush Corporation for the lighting of a portion of the City still hangs fire, although there is good reason to expect that an agreement will eventually be arrived at. Meanwhile, in order to lose no time unnecessarily, the corporation are applying to certain of the vestries through whose jurisdiction the mains will pass for powers to take up the streets. The present intention is to generate current at the company's works at Belvidere-road, Lambeth, and to carry the cables along Stamford-street and over Blackfriars Bridge. The Vestry of St. George-the-Martyr, before whom an application of this nature came on Tuesday last, appeared somewhat inclined to deal with the matter in a hostile spirit, although apparently only about fifty yards of their roads, are affected. Eventually, however, the matter was referred to the Roads Committee.

THE THOMSON-HOUSTON FACTORY AT LYNN, NEAR BOSTON.—*Apropos* of the recent visit of the members of the National Electric Light Association of America to the works of the Thomson-Houston Company, at Lynn, the *Electrical World* remarks that the establishment is one of the largest of the kind in the world. At the present time over 700 men are employed, and the new wing about to be built will more than double the productive capacity. Some idea of the magnitude of the work may be formed from the fact that the arc light department can turn out 300 lamps weekly and is now in full blast. The factory building, which is four stories high with a floor space of about 80,000 square feet, requires some 450 h.-p., is lighted by 120 arcs and 300 incandescents, heated by steam, and is furnished with ample water from artesian wells on the premises. The visitors were conducted over the whole of the works, and were even allowed to witness the art and mystery of the manufacture of incandescent lamps in all its stages.

RULES FOR FIXING OVERHEAD WIRES IN NEW YORK.—The Board of Electrical Control in New York recently issued a set of rules regulating the construction of overhead wires in the city, "pending the providing of underground accommodation." Some of the clauses have, however, since been referred to an electrical engineer for revision. The important provisions are those limiting the lines of poles to but one on each side of a street or avenue, for similar electric service. The poles for electric lights are to be 20ft. high, and at least 8in. in diameter at the base; and of iron, with wood cross-arms. Other poles to be at least 60ft. high. All poles to be at least 10ft. from any lamp-post or other pole; and all poles, new and old, to be plainly marked with the initials of the company owning them. No arc electric light or power wires are to be strung over any portion of a house or building. No new wires to be stretched in streets where conduits are, or are being provided. There are also provisions limiting the time that poles may lie upon the ground before erection.

MANUAL TRAINING IN ELEMENTARY SCHOOLS.—An admirable paper on this subject was read at the British Association meeting by Mr. Mather, M.I.C.E., and which bears out entirely the views on technical education frequently advocated in this journal. The training he proposes is neither for any particular handicraft nor in any special branch of science, but is designed to teach children how to observe, how to use, and how to create. The only manual instruction, the author points out, that is given by our national school system is in handwriting; and Mr. Mather, who is a large employer of persons educated under this system, speaks of it as an utter failure—boys who have attained high distinction in the schools often betraying complete dormancy of the constructive faculty. The system advocated by Mr. Mather, and for the particulars of which we must refer our readers to the paper itself, is becoming very popular in the United States, where some very remarkable results have already been obtained. We regret to notice that the idea was not well received at Manchester.

THE CHARTERHOUSE SCIENCE AND ART SCHOOLS.—The Winter Session of this, one of the largest Science and Art Schools in the United Kingdom, will commence on Saturday, October 1st, 1887, under the presidency of the Rev. Henry Swann, M.A. During the late session about 950 students, mostly elementary teachers, availed themselves of the privileges afforded by this institution, and of this number upwards of 650 presented themselves for examination, and were successful in obtaining a large number of first class certificates and also a goodly number of first and second class honour certificates awarded by the Science and Art Department of South Kensington. Of eight students prepared for the Lond. B. Sc. (Int.) examination, only one student failed; the others highly distinguished themselves. Instruction of a practical character is given in most of the sciences at a very nominal fee; whilst in art, at an equally low rate, students, under the direction of five competent instructors, can be advanced in their studies. Both day and evening classes are held, full particulars of which may be obtained from Mr. C. Smith, organising secretary.

MEETING OF THE ASSOCIATION OF EDISON ELECTRIC LIGHT COMPANIES.—The fifth semi-annual convention of the Association of Edison Electric Light Companies of America has just been held at Altoona, when the following resolutions were carried: That in consequence of the fact that "Underwriters'" wire, so-called, has been shown by experience to be unreliable and treacherous in its action, we regard it as introducing injurious possibilities in all interior wiring; we discountenance its use and urge upon the attention of the companies composing this association the desirability of abolishing it entirely in the work of wiring buildings over which they severally exercise a control. That we extend to the Edison Electric Light Company our cordial and moral support, and an assurance of our conviction that the present unprincipled rivalry now affecting some of the local companies here represented will be speedily terminated by decisions in favour of the Edison patents, thus bringing to justice all who have ignored the rights granted by the patent laws of the United States to the Edison Company, as the heirs of Mr. Edison's electric light invention.

ELECTRIC TRACTION IN MINES.—The employment of electric traction in mines, although one of the earliest permanent applications of electric motors (of large size) in Europe, has somewhat singularly only now received its first illustration in America. The Short Mountain Colliery, in Pennsylvania, has just been furnished with plant for working an underground line about one mile in length. The line has several steep gradients and some sharp curves; it has, however, been found prac-

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ticable to adopt a relatively high rate of speed, and with a train of 10 mine waggons, representing a total weight of nearly 50 tons, it is stated that the distance is run in six minutes, or at the rate of ten miles an hour, the motor being rated at 25 horse-power. The current is taken off from a third insulated rail. By mule-power, previously employed, half an hour was occupied in the same amount of haulage. The contract was carried out by the Union Electric Company, who have put in a steam engine capable of developing 130 horse-power, believing that the system will shortly be extended to other parts of the mine. This example is certain to be extensively followed in the States.

THE PYRO-MAGNETIC MOTOR.—In our issue of August 26th, 1886, will be found an account of a simple experiment by M. Schwedoff, in which the direct conversion of heat into mechanical motion by the aid of magnetism is illustrated. M. Schwedoff takes a small ball of iron and suspends it by a wire in front of a Bunsen flame. He then brings a magnet to the other side, the ball is attracted, moves into the flame, loses its magnetic power and retreats, cools down, and is again attracted, and so on; work being done at the expense of the heat of the flame. The same phenomenon was, however, demonstrated at a still earlier date, and perhaps more effectively, by Profs. Houston and Elihu Thomson. The *Journal* of the Franklin Institute for 1879 contained a description of this experiment. A thin disc of wrought iron was mounted on a spindle and placed between the poles of a horseshoe magnet, with its plane parallel to the lines of force. If now a portion of the disc be heated the attraction of the magnet upon the opposite side is unbalanced, and a slow rotation ensues. This early reference is referred to in a letter by Carl Hering in the *Electrical World*.

MAGNETISM AND MORPHOLOGY.—Some experiments have been placed on record—we forget for the moment by whom—in which a number of eggs were hatched out in a magnetic field, with the result that the chickens were all more or less deformed; blind, deaf, or lame. A biologist at Manchester, in course of conversation, told us that he had several times tried to repeat the experiment, but with the result that the eggs were always addled. Without professing to expound the physiological or morphological reasons for these singular results, it is at least permissible to suppose that the movements of the protoplasmic substance in the magnetic field set up currents of electricity, which tend to decompose the delicate organic structures of the egg so as to destroy or vitiate its vitality. We recommend the study of this very interesting question to the people of Southsea and the neighbourhood, who we learn are continuing to derive unspeakable advantages from a frequent resort to Captain Arthur H. Byng's patent electrified rooms. So successful has been the original company, that it has recently been reconstructed with a view to extending its operations to London and other large towns; in fact, we hear that its advent in the West End may shortly be expected.

LIGHTNING CONDUCTORS.—The following letter from Prof. Tyndall appeared in *The Times* on Tuesday last:—"The question of lightning conductors needs further ventilation. The letter which you allowed to appear in *The Times* of August 31 has brought me ampler proof of the ignorance or carelessness sometimes displayed by architects and builders in relation to this question. Various applications have reached me regarding chimney stacks and edifices to which lightning conductors, *minus* the absolutely necessary earth-plates, have been attached. To such applicants for advice I would reply practically by saying that my own house in the country is provided with conductors manufactured and set up by Mr. Anderson, of the firm of Sanderson and Co., Leadenhall-street—introduced to me by the late excellent Dr. Mann, who had devoted much attention to this special subject. Other workmen equally good are, I doubt not, to be found, but accident or good fortune threw Mr. Anderson in my way, and with his work I am thoroughly satisfied. I may add that the sums set apart by architects and builders for the erection of conductors are often totally inadequate to cover the cost of them. Scant provision on this score may be one reason for omitting the terminal plates, and thus failing to provide a safe earth connection."

MR. TROTTER'S METHOD OF REGULATING DYNAMOS FOR CONSTANT CURRENTS.—It is at all times a somewhat ungracious task, when an independent discovery or invention has been made, to have to point out that it belongs to the wide category of things true but not new. Yet in the interests of historical accuracy it is a task which we are frequently obliged to perform. This is the case with regard to Mr. A. P. Trotter's very beautiful method of "maintaining constant current with varying electromotive force from a dynamo," which was described before the British Association on the 4th September, and appeared in our columns last week. The following paragraph is taken from a supplement issued with this journal on the 31st July, 1885, and was written by Mr W. M. Mordey:—"There is another plan, one which has found several advocates, amongst them Edison. According to this it has been proposed to vary the field, not by alteration of the magnetising current, but by having a non-magnetic gap in some part of the magnet, usually the yoke, which gap could be filled to the required extent by a movable iron plug playing the part of a variable 'magnetic resistance;' or by placing a 'keeper' on the poles which acted as a magnetic shunt on the armature, in the manner familiar to us in the magneto-electric stocking or 'medical' coils to vary the power of the field-magnet." We are not, however, aware of any successful application of this principle prior to its re-invention by Mr. Trotter.

CARBON AS THE POSITIVE ELEMENT IN A PRIMARY BATTERY.—A new primary battery has been devised by Mr. Willard Cease, of Auburn, in which carbon is consumed in chloric acid, the negative element being platinum. The E.M.F. of the cell is 1·25 volt. From the highly explosive character of the substances employed it is evident that the cell cannot have more than a theoretical degree of interest. The arrangement adopted by Mr. Cease is the following:—Crushed carbon moistened with sulphuric acid is placed in a porous pot, surrounding a carbon plate to which a terminal is affixed. Strong sulphuric acid is placed in the outer cell together with the negative platinum element. To the acid chlorate of potash is added in small quantities; peroxide of chlorine (ClO_2), which dissolves in the acid, gradually producing a yellowish red coloration. This solution of chloric and sulphuric acid is, as is well known, one of the most powerful oxidising agents that can be prepared. As soon as the solution has percolated the porous jar the carbon is attacked with the formation of carbonic dioxide, and an E.M.F. of 1·25 volt is set up. The cell should be kept in the dark and at a low temperature. At 140deg. F. peroxide of chlorine explodes with violence, and exposed to sunlight it is decomposed. A drop of this liquid touching the skin leaves a nasty wound. The cell polarises to a certain extent. The action can of course be obtained in a single cell and with a simple carbon plate, but the action is quieter and more steady when a porous pot is used.

THE ARMINGTON-SIMS ENGINE.—Messrs. Greenwood and Batley, of Leeds, send us an extract from a pamphlet issued by

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the Edison Electric Light Company, New York, entitled "The Edison System of Central Station Lighting," in which the Armington-Sims engine is referred to in very flattering terms. "In the early history of our business," says this Company, "it was discovered that high speed is essential to steadiness of light, and all the best known engines in the market were thoroughly tested. Several were found fairly well adapted to running dynamos in isolated plants, but there was nothing that would run successfully in multiple arc, *i.e.*, where two or more engines were operating dynamos delivering their current into one common main or conductor. This is a condition existing in all our central stations, and one which no other company has as yet been able to acquire. In order to supply this urgent need, Messrs. Armington and Sims, of Providence, R.I., made what is known as the 'Armington and Sims' engine, which was partly evolved from the best points of several of the best engines then in use, but with entirely original and distinctive features, specially designed to meet our particular requirements. It is a horizontal high-speed, short-stroke, automatically variable cut-off engine, with a balanced piston valve, compactly built, perfectly balanced, and in the matter of strength is constructed with special reference to withstanding the strain of the high speed at which it is run. As is well known, the engine was eminently successful, and has given great satisfaction everywhere. There are now in use, in connection with Edison dynamos alone, about 300 of those engines, and our experience with them compels us to endorse them as the only engines that have been thoroughly tested for central station work."

Opposition to Electric Light at Leamington.—A memorial to the Local Government Board, it is stated, is being prepared, praying that the application of the corporation for a loan to provide the "fixtures" for the electric light may not be granted. The memorial states: 1. That, in the opinion of the memorialists, the proposal by the corporation to light the principal streets and principal buildings of the town of Leamington by electricity is wholly unnecessary, and will be productive of considerable expense without any corresponding benefit. 2. That as a street illuminant the incandescent lamp, which is the one proposed to be used in Leamington, has been used in London and other towns, and has, they believe, in nearly all instances been abandoned. No inquiries have been made by the council on this head. 3. That the Midland Electric Light and Power Company (Limited), which is the company executing the works in Leamington for the supply of electricity, has obtained no license or provisional order from the Board of Trade, in pursuance of the Electric Lighting Act, 1882, to light the town, and is consequently put under none of the regulations and conditions mentioned in Section 6 of such Act. 4. That only some two years since the corporation expended a sum of £250 in new gas fittings in the town hall, all of which it is now proposed to do away with, and to expend therein £479 in fittings for the electric light. 5. That no agreement whatever has been come to with the council and the Midland Electric Light Company with reference to the method of supplying the electricity beyond what took place in a conversation between the representative of the company and the council, and which has already been broken as regards the time in which the electricity was to be supplied. In the event, therefore, of the light not being a success, the money now proposed to be expended will be thrown away. 6. That gas is exceedingly cheap in Leamington, the price to the public lamps being only 2s. 7d. per 1,000ft. And, therefore, the memorialists are of opinion that the proposed scheme of lighting the streets and public buildings with electricity will be detrimental to the interests of the town, and they pray the Local Government Board not to sanction the loan applied for for this purpose.

The Telephone, the Railway Companies and the Post Office.—The Western Counties and South Wales Telephone Company have long been wishful of establishing a public call office at the Bristol Joint Railway Station. Negotiations were commenced on October 14th, 1886, but have as yet led to no result. The nature of the obstacles existing may be gathered from the following copy of a memorial to the Postmaster-General, which has been signed by the president and officers of the Bristol Chamber of Commerce :—

To the Right Hon. H. C. Raikes, M.P., Her Majesty's Postmaster-General.

The humble memorial of the Bristol Incorporated Chamber of Commerce and Shipping showeth, that your memorialists learn that a telephone call office has been erected at the Bristol Joint Railway Station for the convenience of subscribers to the Western Counties and South Wales Telephone Company, who may arrive at or depart from the station, or who may desire to communicate with their offices or other subscribers, but that unfortunately the said office has not been opened, in consequence of a difficulty having arisen between your department, the telephone company, and the Great Western Railway Company. Your memorialists are informed that the railway company object to sign an agreement with your department on the ground that your department have no exclusive rights on the station property. Whereas, on the other hand, should the office be opened without this agreement being duly executed, your department threaten that the general license of the telephone company for the whole of their district would be cancelled. That on reference to a letter from your department, dated 4th June, 1887, addressed to the secretary of this chamber, in reply to an inquiry as to whether your department would offer any objection to the opening of call offices by that company, it was stated that, under the license of the Postmaster-General, the company were permitted to establish exchanges and call offices in any town in the United Kingdom without obtaining any further consent from your department. That your memorialists much regret that the call room still remains unopened, as it would be a great convenience to the public, and they are of opinon that the general license of the telephone company ought to cover the opening of the said office. Your memorialists therefore humby pray that your department will be pleased to remove the obstacles in the way of the use of the said telephone call office.

Nobili's Rings and Allied Electro-Chemical Phenomena.—Herr Elsas (in the *Ann. Phys. Chem.*) expresses the opinion in opposition to Voigt, that Nobili's rings are mainly due to currents which traverse the electrolysed liquid nearly parallel to the metal plate. The colours obtained are not in all cases colours of thin plates; but the rings are sometimes deposits of different chemical and physical constitution. In fact, electro-chemical decomposition takes place not only at the surfaces of the electrodes, but at every point throughout the liquid traversed by the current. This is proved as follows. Plaster of Paris moistened with copper sulphate solution is poured on a metal plate, and a copper wire plunged into the still soft mass with its end very close to the plate. The plaster is allowed to set firmly, and a current is passed from wire to plate. On removing the cake, four or five coloured rings are seen on its surface, corresponding rings being found on the plate. The plaster also adheres to the metal more or less firmly in different zones, and is also distorted. The central area opposite the wire is green (CuH_2O_2?), and is surrounded by rings successively white, blue, white, red (Cu) and again blue. When the current is long continued, coloured deposits are also found throughout the mass of the gypsum. The

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colours of the rings are independent of the nature of the metal plate, when the latter does not directly act on the electrolyte. When the anode wire is of platinum, the electrolyte becomes acid and pure copper is nowhere deposited. When it is of iron, rust-coloured rings are found in the gypsum plate, showing that transference of the ions takes place even in the solid. If the metal plate is made the anode, a blue circle appears round the cathode, surrounded by an intensely blue ring. When a current is passed between two wires immersed in a plate of gypsum, prepared as above on a plate of glass, circular coloured rings are formed round each wire. The isochromatic lines do not correspond either with the equipotential lines or the lines of equal current-intensity. If in this experiment a metal plate is substituted for the glass, rings also appear on its surface. These appear to coincide with the equipotential lines only at some distance from the wires. Theoretical views follow as to the distribution of potential in the last case. But the appearances cannot be explained by reference to this alone, as Guébhard imagines.

ELECTRIC COMMUNICATION WITH LIGHTSHIPS. — The report of the committee appointed by the Board of Trade to inquire into the desirability of establishing electric communication between lightships and the shore has just appeared. The evidence went to demonstrate in a most conclusive manner that the value and efficiency of the life-boat service would be vastly increased by the establishment of electric communication. Numerous cases were quoted in which vessels have been wrecked within sight of the lightship, while the weather has been so thick that much valuable time—sometimes many hours—has been lost before the attention of the life-boat station could be attracted. In other cases where lightships are stationed not far apart, the difficulty of telling from which ship the sound of the signal guns proceeded has taken the life-boat in the wrong direction and led to loss of life. All this would clearly be prevented if the lightship were electrically connected with the shore. Nevertheless, the committee report that this is "not desirable" on account of the expense, though they recommend that the experiments which have been carried out during the last three years between the town of Walton and the "Sunk" lightship off the Naze should be continued for another eighteen months. It should be explained that the object of the committee is to endeavour to arrive at the most economical system for general adoption, which, notwithstanding the wording of the report, they fully recognise to be eminently desirable. The experiments at the Naze, although perfectly successful electrically, have yet so far proved extremely costly. The experience obtained has shown that the telephone is the most suitable instrument for maintaining communication. With a receiver at each ear no difficulty is experienced in hearing even in the loudest gale. The length of cable employed is nine knots with an earth return. Daily electrical tests were made showing an insulation resistance in winter of 1,519 megohms, and 172 meghoms in the summer. The resistance of the copper conductor was 0·77 ohm in the winter and 0·81 ohm in the summer. The inductive capacity was about 3·2 microfarads. The temperature of the sea bottom was in winter 44deg. F., and in summer 62·5deg. F. The work was carried out by the Telegraph Construction and Maintenance Company, who have devoted much energy and attention to overcoming the mechanical and electrical difficulty of connecting the ship so as to permit of perfect freedom of motion without danger of fouling the cable.

THE ELECTRIC CURRENT AS A MEANS OF INCREASING THE COEFFICIENT OF FRICTION OF ROLLING CONTACTS.—Many years ago a series of experiments were carried out upon a line of railway in America in order to determine whether it was possible to increase the tractive force of a locomotive by magnetising the tyres. The conclusion arrived at was an unfavourable one, and the experiments led to nothing. The subject has, however, been again taken up by Mr. Elias E. Ries, and in a paper read before the American Association for the Advancement of Science he gives some very interesting information on the subject. The increase in the tractive force of electric tram or railway cars taking off current from the rails has often been claimed as a feature of the system, but no very definite observations have hitherto been made. Mr. Ries is conducting a series of careful experiments of this nature, which are not yet completed, but he is able to state that an electric current traversing a rolling contact increases the tractive adhesion in some cases as much as 50 to 100 per cent., the increase depending on the nature of the substances in contact and increasing with the current. "These experiments," he says, "were originally directed mainly towards an endeavour to increase the tractive adhesion of the driving wheels of locomotives and other vehicles, and to utilise the electric current for this purpose in such a manner as to render it entirely safe, practical, and economical." The best results are obtained by the use of an alternating current of large volume furnished by means of a transformer supplied with a current of higher potential in the primary. It does not, however, appear that the employment of an alternating current is essential to success. One of the driving wheels is insulated from the axle—a matter which, as Mr. Ries states, presents no difficulty—the current passes into this wheel through a brush bearing on the axle, reaching the rail it enters the second pair of wheels, by which it crosses into the opposite rail, and thence, through the remaining wheel and a second brush, it returns to the generator, so that the current traverses the rolling contact of all four wheels. This is Mr. Ries's description of the circuit, but it would seem necessary to insulate the frame either from the wheel with which the second brush is connected, or else from the second pair of wheels; otherwise one of the rails would practically be short-circuited. An E.M.F. of from 0·5 volt to 1 volt only is required, but the current does not appear to have been measured. It will be seen that the arrangement is a perfectly safe one, as only that portion of the rails which lies at any moment between the two pairs of driving wheels is included in the circuit. The arrangement need not of course be always in use; if desired its employment can be restricted to the ascent of heavy gradients, when the rails are in a particularly slippery state, or for especially heavy loads. A different and probably better method of attaining the same result has also been devised by Mr. Ries. This consists in magnetising the axle or axles of the driving wheels by means of a coil surrounding the shaft. A closed magnetic circuit is thus established through the wheels and rails. A model car, fitted with this arrangemeent, was exhibited, and by means of a dynamometer it was shown that the tractive force was increased nearly 200 per cent. when the circuit was closed. The model car was able to ascend a gradient of 1 in 3, and easily remained at rest upon an incline of 1 in 2½ when the motive power was shut off. It even required considerable force to push it down this incline, while without the magnetic arrangement it was of course unable to maintain its position. It is further obvious that the same principle can be applied to the brakes. This idea has been carried out in a very simple and ingenious way by Mr. Ries. The brake shoes are ordinarily held off from the wheel by being magnetised in the same direction. On the reversal of the current in one of the coils the shoe is strongly attracted, constituting a very powerful brake.

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ON A PRACTICAL METHOD OF MEASURING THE COEFFICIENTS OF SELF AND MUTUAL INDUCTION.

BY GUY C. FRICKER.

Since the development of alternating current dynamos and of distribution by means of induction coils,* a number of methods for determining the coefficients of self and mutual induction have been devised.

For the most part these involve operations of too delicate or laborious a character to find favour with practical electricians.

It is true that the method described by Mr. T. H. Blakesley,† whereby the coefficients L and M may be found by aid of certain observations on a Siemens dynamometer, is a distinctly practical and excellent one, involving the use of no special apparatus. A slight modification in the usual arrangement of the instrument is, however, essential to it.

It occurred to the writer that the known relations between the angle of retardation of the current and the impressed force, so conveniently expressed by Mr. Blakesley's diagrams, would furnish sufficient data for another, and perhaps in some ways, a still more convenient method of determining L and M than that given in his book.

The procedure is as follows:—

Single Circuit.—Take on open circuit the reading of a Cardew voltmeter giving ·707 E, where E = the maximum value of the impressed E.M.F. Denote this by the line A B in Blakesley's triangle (Fig. 1) and call it a.

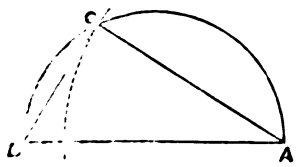

FIG. 1.

Next close the circuit through a non-inductive resistance, and adjust the same until a certain current, which should be large, is indicated on a Siemen's dynamometer, and take a second reading, β, on the voltmeter.

The dynamometer measures $\frac{I^2}{2}$, where I is the maximum value of the current; thus

$$I = \sqrt{2 \times \text{dynamometer reading}} = \sqrt{2C}.$$

Then if r is the internal resistance of the dynamo, $r\sqrt{2C} + \frac{\beta}{\cdot 707}$ = the maximum value of the effective E.M.F., which call h.

On A B as diameter describe the semi-circle A B C, and from the centre A at the distance h describe an arc cutting the semi-circle A B C in the point C; join A C,

then $$L = \frac{RT}{2\pi} \tan B A C,$$

where R is the total resistance of the circuit and T is the periodic time.

Two circuits.—Place the voltmeter in the secondary circuit, otherwise open, and pass a current of maximum value, I_1, through the primary. The current indicated by the dynamometer can be called C_1.

The reading on the voltmeter then gives ·707 × the maximum value of the impressed E.M.F. on the secondary, and is represented in the diagram (Fig. 2) by the line C E.

At right angles to C E set off C F, equal to $I R_1$, where R_1 is the total resistance of the primary circuit, and join F E;

then $$M = \frac{R_1 T}{2\pi} \tan C F E.$$

Next, keeping the primary current constant, take the dynamometer reading $\frac{I_2^2}{2} = C_2$ in the secondary, and also a second reading (γ) on the voltmeter. Then, as before, $\frac{\gamma}{\cdot 707} + R_2\sqrt{2C_2}$ = the effective E.M.F. in the secondary, where R_2 is the resistance.

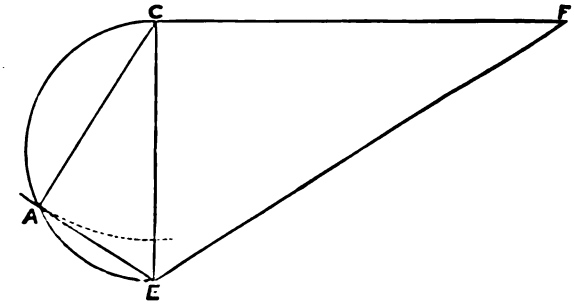

FIG. 2.

Setting this out within the semi-circle C A E the angle A C E is obtained, and if L_1 = the coefficient of self-induction in the secondary

$$L_1 = \frac{R_2 T}{2\pi} \tan A C E.$$

To find L in the primary the circuits are reversed.

It is evident that the formula $\frac{RT}{2\pi} \tan \phi$, where ϕ is the angle of retardation, must be a constant, and therefore independent of the current.

For in the triangle A B C the effective E.M.F. $E \propto \cos \phi$ and the E.M.F. of self-induction $E_1 = I L = \frac{E}{R} L \propto \frac{L}{R} \cos \phi$.

Also, $$\tan \phi = \frac{E_1}{E} \propto \frac{L}{R};$$

$$\therefore R \tan \phi \propto L.$$

* This point will be dealt with in its proper place in the articles on "Dynamo Design"; but in view of the interest attaching to all questions relating to distribution by alternating currents, it has been thought that the following might well appear as an advance note.

† See *Electrician*, Vols. XIV. and XV.

ON THE CONDITION OF MAXIMUM WORK OBTAINABLE FROM A GIVEN SOURCE OF ALTERNATING E.M.F.*

BY GISBERT KAPP.

The following investigation applies to all cases where the whole of the work is done in the circuit which receives current from some source of supply having an impressed alternating E.M.F., but it does not apply to those cases where the E.M.F. is impressed on a primary and the work is done in a secondary circuit. As an example, take the case of glow or arc lamps fed in parallel connection direct from two mains between which is maintained an E.M.F. alternating according to a simple sine function. We assume the mean value of this E.M.F. as measured by a Cardew voltmeter or a Thomson electrometer to be maintained constant whatever may be the quantity of current taken by the different lamp circuits, and the periodic time of the wave of impressed E.M.F. to be also constant.

We also assume that each parallel contains a portion having a sensible self-induction, and the problem is to find what resistance should be given to the lamp in order to use up or rather transform in it a maximum of energy with the given impressed E.M.F. With a unidirected and constant E.M.F. the lower the resistance the greater would be the energy used up in the lamp; but this is evidently not so in the case of an alternating E.M.F., since upon short-circuiting the lamp completely the current does not exceed a certain maximum—which is determined by the self-induction of the circuit—and during a gradual reduction of resistance of the lamp, the current, being one of the factors determining the work, remains therefore finite, whilst the other factor (the E.M.F. over the lamp terminals) approaches zero. A maximum of work can there-

* Paper read before the British Association Meeting, at Manchester, September, 1887.

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fore not be obtained by the simple expedient of reducing the resistance of the lamp to its lowest possible value. That an excessive increase of resistance will not accomplish the desired effect is self evident, and we are thus led to the conclusion that between these extreme values of resistance there must be at least one special value for which the work done in the lamp becomes a maximum. The value of this particular resistance must naturally depend upon the E.M.F. of supply, the periodic time, and the self-induction of the circuit.

Before proceeding further it will be convenient to point out that the same consideration applies to a circuit fed from the secondary coil of a transformer, the primary coil of which is connected in parallel across the mains from an alternate current machine. In this case the E.M.F. appearing on the terminals of the secondary is very nearly constant if the E.M.F. between the mains is kept constant, a condition which must necessarily be fulfilled in a network of mains for public supply of electricity on the parallel system. We may therefore consider the E.M.F. induced in the secondary coil as an E.M.F. impressed upon the terminals of the circuit in which the work is to be done, and thus our problem becomes applicable both to the direct supply and to the supply by means of transformers.

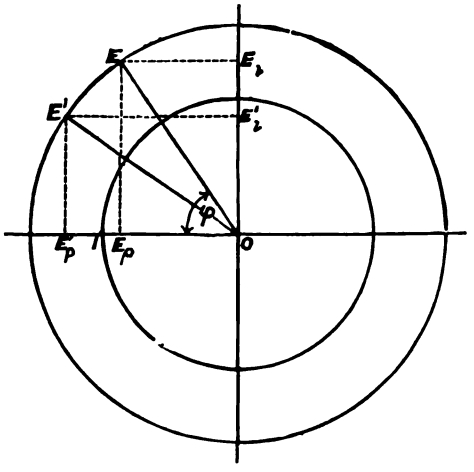

FIG. 1.

Let in the diagram O E = E represent the impressed E.M.F., and O I = I the resultant current, both being maxima—that is, the crest of their waves—and let ϕ be the angle of lag. The maximum value of the E.M.F. due to self-induction is then obviously given by the line $\overline{O E_\iota} = E_\iota$, and the maximum of E.M.F. necessary to overcome the inert resistance of the circuit is given by the line $\overline{O E_\rho} = E_\rho$. If r denotes the resistance and L the self-induction, we have $E_\rho = r I$, and $E_\iota = L I 2\pi n$. The angle of lag, as is well known, is determined by the relation

$$\tan \phi = \frac{2\pi n L}{r}.$$

We may now represent the impressed E.M.F. and the resultant current at any moment, as the projections of the two lines O E and O I on the vertical, these lines being supposed to revolve round O at a fixed speed, and to always maintain their angular distance ϕ. Let α be their angular advance at the time t, then $e = E \sin(\alpha + \phi)$ and $i = I \sin \alpha$ represent E.M.F. and current at that particular moment, and

$$d W = E I \sin(\alpha + \phi) \sin \alpha \, d t$$

represents the work done during a further angular advance during time $d t$. If $T = \frac{1}{n}$ be the periodic time $\alpha = 2\pi n t$, and the above equation can also be written as follows:—

$$d W = \frac{E I}{2\pi n} \sin(\alpha + \phi) \sin \alpha \, d \alpha.$$

By integrating between the limits $\alpha = 0$ and $\alpha = 2\pi$, we obtain the work done during the time T (that of a complete period), and by dividing the result by T we obtain the work done in unit time, or the rate of doing work as generally expressed in watts. The operation gives

$$W = \frac{E I}{2} \cos \phi \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Since the mean value of E.M.F. and current measured by instruments is $\frac{1}{\sqrt{2}}$ of their maxima, we have also

$$w = e i \cos \phi,$$

e and i being these mean values. This expression enables us to determine the work done from readings taken with a voltmeter and a current dynamometer, provided we know the resistance of the circuit. From the diagram it will be seen the angle of lag is found by the formula $\cos \phi = \frac{i r}{e}$, and substituting we obtain $w = i^2 r$, which is self-evident. This result might have been obtained without introducing the E.M.F. at all; but, as will be shown presently, the investigation applies also to cases where, besides an inert resistance, there is a counter E.M.F. in the circuit, and then the term $i^2 r$ is not a correct measure for the work done, and the more general expression given in equation (1) must be used.

From a commercial point of view it is important that the lag should be small, because the size of the dynamo and mains is governed by the product E I, whilst the work done by the dynamo is governed by the product $\frac{E I}{2} \cos \phi$, and it is evident that if ϕ be very nearly 90deg. we would require an enormously large plant to do comparatively little work. Generally speaking, the size of the plant for a given amount of work will be inversely proportional to cos ϕ. In a continuous current system there is no lag, and the whole volt-ampere capacity of the plant is actually available for useful work; in an alternate current system this capacity becomes reduced in the ratio of 1 : cos ϕ, and cos ϕ might therefore be considered to represent the plant efficiency of the system.

Returning now to the original problem we have to find the condition under which the work E I cos ϕ, and therefore I cos ϕ, becomes a maximum. From the diagram we see that E_ι or $2\pi n L I = E \sin \phi$, and therefore $I \cos \phi = \frac{E}{2\pi n L} \sin \phi \cos \phi$. To make this a maximum the angle of lag must evidently be 45deg. The same result has been found analytically by Mr. Snell, and published in his articles on "Alternating and Induced Electromotive Forces," in *The Electrician* of August 13th, 1886. Graphically, the projections of O E on the horizontal and vertical must have equal length—that is to say, E_ι must be equal to E_ρ. Maximum work is done in the circuit if the E.M.F. of self-induction equals the E.M.F. necessary to overcome the inert resistance. In this case the following relation must evidently obtain $r = 2\pi n L$, and by choosing the resistance so as to satisfy this equation we obtain a maximum of work from the given mean E M.F. e, and in a circuit of given self-induction L. The E.M.F. which is used to drive the current through this resistance is ·709 of the impressed E.M.F., and this figure represents also the plant efficiency of the system.

The above law of maximum work is capable of application to the case of a series-wound electromotor worked by an alternating current. An ordinary series-wound continuous current motor can be worked by an alternating current if the field is sufficiently laminated to prevent the formation of eddy currents. There are certain reasons which render it inexpedient and uneconomical to work any apparatus for the utilisation of alternating currents at high degrees of saturation, so that in practice the strength of field of such a motor can be considered as strictly proportional to the current at any moment. In a motor of this kind the flow of current is opposed not only by its inert resistance, but also by the counter E.M.F. developed in the coils of the armature. It is evident that at constant speed of rotation the latter opposing force is proportional to the strength of field, and therefore also to the current, and it is of the same character and period as the E.M.F. necessary to overcome the inert resistance of

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the circuit. Retaining the above notation, and writing ki for the counter E.M.F. of the armature, where k is a coefficient depending on the constructive data of the machine and on its speed, but not on the periodic time and self-induction, we have at any moment $e_\rho = (r+k)i$, and the condition of maximum work is $r+k=2\pi n$ L. In order that the motor may absorb maximum work, it should be so constructed that the sum of the counter E.M.F. of the armature and the E.M.F. necessary to overcome its inert resistance equals the E.M.F. of self-induction. In order to obtain a high efficiency, r must be small as compared with k, and in this case we may as a rough approximation neglect r, and say that the motor will give out maximum work if its counter E.M.F. equals the E.M.F. of self-induction. This law has a striking resemblance to Jacobi's law of maximum work obtainable from a continuous current motor. There the condition is that the counter E.M.F. should equal the E.M.F. necessary to overcome the inert resistance of the circuit; but whilst in this case the commercial efficiency must be less than 50 per cent. in the alternate current system it may be much more. In so far the alternate current motor would seem to have an advantage over the continuous current motor, but this advantage could scarcely be realised in practice. On the one hand, we never work continuous current motors with maximum output, whilst on the other hand it will be found extremely difficult, not to say impossible, to work a series-wound motor by an alternating current of reasonably short period in such a way as to satisfy the above conditions for maximum work. It will generally be found that in a motor of this type, owing to the great magnetic inertia of the field, the E.M.F. of self-induction is considerably greater than the counter E.M.F. of the armature, and that to increase the latter without at the same time increasing the former we should require to run the armature at too high a speed. But even if we cannot completely fulfil the condition of maximum work we can at least attempt to approach it, and the above investigation may serve to show in what direction improvements should be made if we wish to solve the practical problem of obtaining motive power from alternating currents. In experimenting with machines of this class it is of course necessary to have some easy means for the determination of the coefficient of self-induction, angle of lag, and plant efficiency. These points can be easily determined by means of the diagram. Two experiments only are required. First, note the mean current and mean terminal pressure when the armature is prevented from revolving; and, secondly, note the mean current when the armature is revolving and doing work, the terminal pressure being adjusted to have the same value as formerly. Let, in the diagram, the line O E_ρ represent the E.M.F. required to overcome the inert resistance of the motor. This can be calculated from the known resistance and the measured current. By erecting a perpendicular in point E_ρ, and prolonging to the point of intersection with the circle representing the impressed E.M.F., we find the point E, the angle of lag ϕ, and the horizontal projection of O E gives O E_i the E.M.F. necessary to overcome self-induction. Since the latter is proportional to the current which has been measured, the coefficient of self-induction can now be determined. When the armature revolves, the current becomes reduced, and therefore the E.M.F. of self-induction assumes a proportionately reduced value, which in the diagram is represented by the length of the line O E'_i. To this corresponds the point E′ on the circle of impressed E.M.F., and projecting this point vertically we find E'_ρ as the E.M.F. necessary to overcome the counter E.M.F. of the armature and the inert resistance of the motor circuit. The latter can be calculated from the current and resistance, and thus the counter E.M.F. of the armature and the electric energy actually available for conversion can be determined.

TUNGSTIC ACID.—Eisenmann recommends the use of tungstic acid in primary batteries. Its chemical behaviour is very similar to that of chromic acid, but it has the advantage of being rapidly oxidised after reduction. In order to prevent the formation of a precipitate in the cell the addition of a small amount of phosphoric acid is desirable.

CORRESPONDENCE.

RULES FOR INSTALLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Is there any truth in the rumour we hear that electrical engineers are to have yet another burden laid upon them in the shape of another set of "rules," to emanate from themselves as represented by the Society of Telegraph-Engineers and Electricians. Surely we have enough to bear from extraneous sources without ourselves increasing our difficulties. We already possess a good set of rules, the correctness and completeness of which are of world-wide renown, even the United States, as well as the Continent, deigning to take a leaf out of our book by recognising the Phœnix Fire Office rules, of which English electricians ought to be proud. We ourselves have always worked in accordance with these rules, and although we have put up some of the largest installations in the country have never had the slightest trouble with the fire inspectors, even when we have had to meet the redoubtable Mr. Heaphy himself on installations where the fire risk in point of value involved is very large.

To our mind the Phœnix rules fulfil all requirements, and whatever new hobbies the above-mentioned society may see fit to perpetuate in their fruitless endeavours after notoriety, we are sure they will never attain the prestige or universal authority of the Phœnix rules; and speaking for ourselves we do not propose altering our system, and shall continue to specify in our contracts and to erect our installations in accordance with the Phœnix Fire Office rules. Within the last few days we have had practical experience of the trouble we are likely to encounter daily if the ridiculous action of the Society of Telegraph-Engineers be persisted in.—Yours, &c.,

14th September, 1887. ELECTRICAL ENGINEERS.

THE D'HUMY BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is a pity that your space is too valuable for the entire reproduction of the prospectus of "The Water Primary Battery Company (Limited)" and the press comments thereon, for I venture to say that documents more worthy of careful consideration and study it has seldom been my lot to examine. But since such be impossible, I trust that the following remarks and abstracts may in some way compensate your readers for the loss they have sustained in not being able to personally enjoy what is at once erudite and profound.

I will pass over the opening statement that "prior to the invention of *this* water battery it was deemed practically impossible to charge accumulators and store electricity with primary batteries" by expressing my astonishment at our general ignorance in not being aware of this fact before. At the same time it does not appear in what way *this* water battery has accomplished this feat, which the other water batteries failed over; we assume it *washed* away the difficulty. Possibly this great discovery was due to that eminent electrician—figuring in the prospectus—who one day assured me that an accumulator could be charged and discharged at *one and the same time*. I told him I had hitherto been led to understand that "charge" meant flow in a given direction, and "discharge" flow in the opposite direction, and therefore I presumed he somehow commutated his currents. "Not *exactly* that," he replied.

The chief points set forth as distinctive features of this battery are:—

1. "It produces a steadier and more constant and reliable light." Pity it is not *quite* steady; but this defect may be remedied in a future edition. Pity it is not quite constant; but since we are led to infer (Ye gods! who could doubt it?) that the E.M.F. is constant under varying loads, and knowing that the internal resistance is high, this battery is indeed truly and wonderfully made.

2. "The first cost of installation is far less than the cost of a dynamo and attendant steam or gas engine." A most desirable feature, and one which especially recommends itself

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to contractors. For example, Mr. D'Humy is able to sell plant (*i.e.*, generating plant) sufficient for 25 10 candle-power lamps per £100. His charge, therefore, for 50 20 candle-power lamps would be about £350! Astonishment sways the quivering pen. Are not these figures quite sufficient to give a death blow to the engine and dynamo?

3. "The cost of maintenance is trifling by comparison." I have no doubt of it, for I have been favoured with some figures by one to whom Mr. D'Humy gave them direct, which give the remarkable result of $\frac{1}{16}$th of a penny per 20 candle-power lamp hour.

En passant I may mention that the output of each cell is arrived at in a charmingly simple fashion. Mr. D'Humy takes the current on short circuit and the E.M.F. on open circuit, multiplies these together, and arrives *at the output of each cell.* Happy thought. Send round Mr. D'Humy to all the dynamos in London to test their output in *the same way.*

4. "The battery is more convenient of storage." True, this battery is larger than any other existing battery, heavier, more bulky—in fact, it is "very fine and large," but, no matter; for

5. "No skilled and very little unskilled labour is required for its manipulation;" therefore it may be stowed away in half a dozen old barns, sheds, or pigsties.

7. "The batteries give off no noxious fumes;" for this reason the pigsty is the preferable place for them. Nitric acid never did give off noxious fumes. If the pigsty is leaky so much the better, for

8. "The chief liquid used is plain water," and so the "very little unskilled labour" may be absolutely dispensed with in wet weather.

9. "The economy of the battery is perfect." Hence we have $Z = 1$, a most admirable result, and one which, indeed, was to be expected, since the internal resistance is *high.*

"It is constant in its action, the storage of electricity never ceasing by day or night." This seems a little mystifying, but no doubt it is "claimed."

11. "The fluid flushed from the cells daily by the supply of fresh water is a slightly acidulated solution of iron, which is a high disinfectant, and most beneficial when discharged into the drains." Another reason for recommending the pigsty. (See remarks 5 and 7.)

The above are the chief points in the D'Humy battery, and at once show its enormous superiority over every other "system;" in fact, "it has at length solved the vexed question of house-to-house lighting by electricity." One cannot help picturing the besieged state in which Mr. D'Humy must have lived since the fame of his "invention" has been noised abroad. Go to No. 26, Gray's Inn-road, and see for yourself. Absolutely impossible! So engrossed is Mr. D'Humy in his "invention" that one has no chance whatever of seeing him, no matter at what hour of the day or night, or even if one waits all day it is impossible to get the desired audience.

In writing all this I am gnawed with pangs of jealousy when I think of the lucky contractor who supplies Mr. D'Humy with carbon plates, with iron, with acid, porous pots, and the like! 200,000 lamps in Madrid alone.

Mr. D'Humy, in comparing gas light with electric, compares what he considers the *actual* candle-power of a gas jet with the nominal candle-power of an electric lamp. This, no doubt, is simplicity, and after all that is the chief thing he isaiming at.

Possibly for the same reason, when comparing the output of his battery with that of the costly engine and dynamo, he takes the *nominal* horse-power of the engine and the product of the E.M.F. on open circuit and the current on short circuit, divided by 746 of the battery. And so one is obliged to agree with *Barker's Trade and Finance*, Aug. 10th, 1887, that "really there is no saying what wonderful achievements are yet to be developed through its (electricity) agency."

I propose to reserve my comments on the newspaper extracts for next week.—Yours, &c.,

ICONOCLAST.

P.S.—BATTERY *(log.)*:

The critics call me "Minehaha!"
"Mine" laughing "ha ha *Water.*"

RADIATION FROM LAMP FILAMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to Mr. Robertson's interesting letter, I am afraid I have not made it quite clear in my articles that the question of roughness or smoothness does not come in as long as the outline of the heated body is the same ("Incandescent Lamp Manufacture XXI."). For instance, Mr. Robertson says:—"I think the points or hills on a dull surface carbon must cut off some of the light radiated from the hollows." I also pointed out that there would be no advantage in using a carbon with a high emissivity, as efficiency would still depend on temperature. So far I can corroborate Mr. Robertson's experiments as to alteration of hot resistance—that is to say, as far as my experience goes there is no apparent connection between hot and cold resistances of carbon.

I have tried very few experiments to determine the relative emissivity of grey and black carbons, and would be very glad if Mr. Robertson would test some of exactly the same surface—that is to say, the same outline in every direction—and see what candle-power they give at the same efficiency.—Yours, &c.,

JAS. SWINBURNE.

[CORRESPONDENCE *continued on page 397.*]

ELECTRIC TRANSMISSION OF POWER.

Now that the theatre at the Newcastle Exhibition has ceased to be used for dramatic entertainments arrangements have been made for the delivery of lectures every Monday and Saturday evening. The first lecture was delivered on Monday evening, by Prof. Garnett, the chairman of the Lectures Committee, the subject being "The Electric Transmission of Power." After brief reference to the methods commonly employed for transmitting power the lecturer referred to the growing importance of electric transmission for railways, tramways, and other purposes, giving various numerical particulars with which our readers are already familiar, and pointing out that although the power employed in electrical traction seemed large, yet the cost at Denver, where 10 horse-power per car is allowed, was only about one quarter of the cost of horse traction, and the cost is, after all, the important question. Some particulars were then given respecting the Messrs. Woodhouse and Rawson tramway in the Exhibition grounds, where the motor takes a load of between 12 and 13 tons up an incline of 1 in 30 and upon a very sharp curve. To take the car and bogey which carries the motor up this incline at the rate at which it travels requires about 24 horse-power on "the tow rope." After exhibiting a number of lecture room experiments illustrating the mutual action between currents and magnets, and the attraction of a solenoid for a turn-screw, &c., a half-horse Immisch motor was exhibited, and driven by the current ordinarily employed for lighting the footlights. The resistance coils which had been arranged for regulating the stage lights were of great service in reducing the E.M.F. (110 volts) in the theatre mains to suit the various motors exhibited. Prof. Garnett having pointed out the close analogies existing between the transmission of power by high-pressure water from an accumulator and the electrical transmission, called attention to the fact that when a steam engine or hydraulic engine is running most rapidly the consumption of steam or water is greatest, but in an electric motor the current diminishes with the speed. A 5 horse-power Immisch motor was then run in series with 28 Swan lamps, and it was seen that as the speed of the motor increased the light fell considerably, but rose almost to full brilliancy when a brake was applied so as to nearly stop the motor, and it was pointed out how the back E.M.F. produced by the motor regulated the current to the load. The analogy between motors and dynamos was then pointed out, and a transformer constructed by Messrs. Paris and Scott, of Norwich, for transformation from 400 volts to 100 volts, was exhibited in action and explained. These transformers have already been referred to in our columns. The machine in question is capable of running about 200 lamps. But the apparatus which evoked the greatest interest on the part of the audience was the set of machine tools lent to the exhibition by Mr. F. J. Rowan, of Glasgow. Two drills and a riveting machine were exhibited suspended from a frame in the front of the stage, and a $\frac{7}{8}$in. lead rivet was closed by the riveting machine, the lecturer, for obvious reasons, ceasing to lecture during the operation. There should be a great future for electro-magnetic machine tools in the shipyards of the Tyne. The half-horse Immisch motor exhibited is employed to drive a Blackman air propeller for the ventilation of the offices used by the cashier and the Finance Committee. The air is drawn through three rooms in succession, and it is needless to say that the ventilation is eminently satisfactory.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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ELECTRICITY IN MINES.

Whether or not it is right that the House of Lords should "dare to dictate to the people's elected," it is certainly right that somebody should exercise a little common sense when legislation on the regulation of mines is in question; and in this relation the non-elected peers have rather the best of the comparison. It may be very desirable to substitute for the Davy and the Stephenson safety lamps some other and better appliance for the protection of workers in mines; but to prohibit the use of these lamps altogether, as the people's elected had done when they sent the Mines Regulation Bill to the Upper House, is something like prohibiting the use of gas in theatres altogether because gas is not the safest mode of lighting. The House of Lords removed this ban from the obnoxious lamps, seeing that the substitution of an absolutely safe lamp to take their place was not made obligatory in the Act, for the sufficient reason that no absolutely perfect lamp has yet been devised, or at all events has not yet been generally accepted. Although the electric lamp is, as we believe, the miners' lamp of the future, it may not in all cases be necessary; and in some cases it may be objected to on quite reasonable grounds. The electric lamp must be tried on its merits, and must fight its way as every other invention has had to do. And this is true also of the electric light for illuminating mines generally. If we wanted any fresh evidence of the good sense of the House of Lords in dealing with the Commons' suggestions it is furnished in the conduct of Mr. Fenwick, who opposed the Lords' amendments apparently because it was the Lords', and of Mr. C. Graham, who got himself suspended for "conscientiously" refusing to withdraw an offensive application of the phrase we have quoted in the opening sentence of this article. Reasonable people will mistrust any legislation whatsoever at the hands of fanatics who make their irrational prejudices a matter of "conscience."

Much as we desire to see an extension of the use of electricity in mines, its compulsory adoption would have given us no satisfaction at all. And this because all reforms of the kind here referred to must, to be really valuable, be adopted with a good grace and carried out with a sincere desire that they shall succeed. Reforms which have not the sympathy of the parties most affected by them are worse than useless, they are absolutely mischievous; for, being introduced unwillingly they are pretty sure to fail, and the result may retard their acceptance much longer than would be the case if they were left to win their way by merit rather than by legislation. It may be feared that some of the provisions of the Mines Regulation Bill which the Government succeeded in passing may fail because the House of Lords put a restraint upon their powers of "dictation;" and because the Bill as it stands is restrictive and vexatious somewhat beyond the limits of common sense and practical statemanship. A far more satisfactory guarantee on this point is the Home Secretary's positive assurance that the Government will do what it can to forward the welfare of miners by encouraging the use of electricity in their dangerous calling. This expression of approval is sufficiently valuable in itself, and, to our thinking, is as much as we can or ought to expect for the present. It may be a matter of conscience with some of our readers that none other than the electric light is desirable or safe in the explosive atmosphere of a mine; but none of them, we imagine, will consider it their duty to force their convictions on other people prematurely and by means of arbitrary legislation.

Some admirable safety lamps maintained by electricity have lately been devised; and we are able to state that electricity as a means of illuminating mines is steadily making progress. To these facts our columns are continually testifying; and we entertain no doubt that in due time a perfectly acceptable electric lamp will find its way into all the deep workings wherever a safety lamp is necessary. And further, that in the majority of mines electricity will rapidly supersede the use of bare lights of every other description. It rests with electrical engineers themselves and with electrical inventors to press their claims on the attention of the mine owners, and this they should do with all the energy at their command. The season of disaster is no doubt the most opportune for making converts, but, on the other hand, as we have just had occasion to point out in the case of the Exeter disaster, the season of security is the time to guard against an impending catastrophe; and, unhappily, where mines are in question the catastrophes are of ever-recurring frequency, so much so that they are treated too often as the unpreventable mishaps necessarily attendant on a dangerous avocation. According to the report just issued by the Chief Inspector of Mines there were 561,092 persons employed in the mines of Great Britain in the year 1886, and of these no fewer than 1,018 lost their lives by accidents of one kind or another connected with the workings. It is fair to assume that the greater portion of these casualties were due to either deficiency of light or the accumulation of explosive gases. It is our business, and the business of our readers, to patiently but steadfastly insist on the fact that these mishaps are not unpreventable, and that their occurrence is largely owing to the neglect of the one and only safeguard which human ingenuity has yet provided.

The importance of this subject was not overlooked at the recent meeting of the British Association, the members of

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which made an excursion to the Astley and Tyldesley Salt and Coal Company's mine for the purpose of inspecting the electric light which had been lately installed in the workings. The mine in question is a comparatively new one, and does not belong to that dangerous class which most urgently call for the introduction of the electric light. But as a mere matter of convenience, the superiority of this form of illumination was demonstrated at Astley; and the impression left upon the minds of the visitors was that mine owners will not be long in discovering how greatly the efficiency of mining operations may be enhanced by the employment of electricity as the illuminant. As regards the gaseous and more dangerous class of mines, Mr. SWAN has made some recent improvement to his safety lamp, the particulars of which he described at the British Association meeting, and which will be duly given in our reports thereof. The device can be used both as a lamp and as a firedamp detector. In the latter capacity it will indicate the presence of this dangerous gas in proportions far below that for which all other known tests afford any evidence; and the operation is entirely free from the risk usually attending such tests by the appliances commonly in use. It has only recently been discovered that the presence of a very small percentage of firedamp in an atmosphere laden with coal dust will result in a mixture which is highly explosive. Hence it is that unlooked for explosions have often occurred in situations which had never been thought dangerous. With this knowledge before us the value of some highly sensitive indicator, such as that invented by Mr. SWAN, can hardly be over estimated; and we sincerely hope that it may prove in practice as convenient and as trustworthy as the ingenious inventor predicts it will be.

THE ELECTRICAL LIGHTING OF TRAINS ON THE GLASGOW UNDERGROUND RAILWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Seeing a paragraph in your last week's issue relative to above, I have to state that two months ago some carriages did not have the contact pulley fixed at the proper height; but these have since been altered, and the lights now are quite as good, if not better, than at first. As I thought you might like to hear the result of six months' work, I beg to enclose note of same. The lamp-hours may not seem many, compared with the lamps in use and the time the trains have been running, but it should be remembered that the lamps are only lit, in the daytime, when the trains are in the tunnels.—Yours, &c., THOS. P. CARSWELL.

Bon-Accord, Douglas Gardens, Uddingston,
September 12, 1887.

Note of six months' working of electrically fitted trains up to 31st July, 1887:—

Number of carriages fitted	74
Number of lamps in use	307
Time lamps have been lit in "lamp-hours"	39,642
Number of lamps renewed	44*

* Eleven of the 44 lamps renewed were broken maliciously by passengers in the trains.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having quite recently inspected the system adopted of picking up the current for lighting the carriages, I can, with some authority, assure you that the report published in *The Electrician* of September 9th is quite ill-founded. Considering the difficulties attending the installation of the system, I think all impartial electrical men will agree that Mr. Carswell has initiated a new departure in railway lighting, which may be termed a "useful and economical compromise" between the old oil lamp and the complete electrical illumination by dynamo and storage batteries fitted to each train. The roller contact worked well, but in some carriages the spring pressure was not enough to cause good contact with the central rail, which is not to be wondered at. The carriages are fitted by the waggon department, who have no opportunity of testing the contact. This difficulty could be immediately removed by having a short line of rails and an electrician at the carriage works.—Yours, &c., KILLINGWORTH HEDGES.

Ballewan, Strathblane.

SELF-REGULATING DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Prof. Silvanus P. Thompson's book on "Dynamo-Electric Machinery" a number of mathematical formulæ are given expressing the conditions necessary for self-regulation in dynamos. I should feel obliged if any dynamo makers could find time to give information as to what extent these formulæ are in accordance with their practice in manufacture.—Yours, &c., M.

Calcutta, 19th August, 1887.

THE FORBES NON-POLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

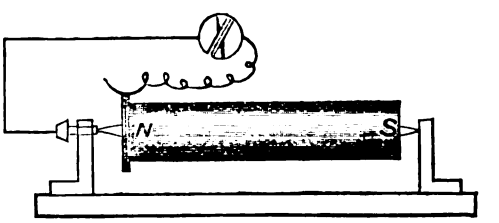
SIR: The typical Japanese is not inapt at drawing in his own particular style, but try to teach him the meaning of perspective, and though you make the facts as plain as pike staves you may waste years in the vain endeavour to make him understand it. To minds destitute of ingenuity what I have written in the course of this discussion cannot have been engaging, save in the way in which it appears to have interested Mr. Thompson, who has most fully misunderstood nearly every suggestion I have made.

Were I to attempt to correct the tissue of errors he makes in the letter published in to-day's *Electrician* the benefit would be very doubtful—good space wasted undoubtedly. He may therefore enjoy the fruits of his ideas, whatever they are, in peace, so far as I am concerned.—Yours, &c.,

Staveley, September 2nd, 1887. R. SNOWDON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To help bear me out I will now quote the immortal Faraday, whose experimental accuracy no one will dispute. In Vol. I., page 63, he says:—"I endeavoured to ascertain whether it was essential or not that the moving part of the wire should, in cutting the magnetic curves, pass into positions of greater or lesser magnetic force." And to prove the point "a copper disc was *cemented* upon the end of a cylinder magnet with paper intervening, *the magnet and disc were rotated together*, and collectors brought in contact with the circumference and the central part of the copper plate. The galvanometer needle moved, and the direction of motion was the same as that which would have resulted *if the copper only had revolved and the magnet been fixed.*" The italics are mine. There is no drawing,



Faraday's Experiment.

so I send you what I think is a fair representation of the experiment. Let us see what bearing it has on our present discussion. Firstly, the disc was cemented to the end of the magnet and rotated with it. If Mr. Thompson is of the same opinion still, he will say the current is the result of the rotating lines of force cutting the stationary conductor leading from the periphery of the disc. Be it so. But, secondly, the magnet was fixed and the disc only allowed to rotate. The fixed conductor must necessarily have been neutral in this case. If we now follow out Mr. Thompson's idea, that the lines are inseparably connected

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with the magnet and rotate with it, we are driven to these conclusions:—In Faraday's first experiment the wire could only be the generating conductor and the rotating disc so much superfluous metal, because a rotating disc could not cut lines of force rotating in the same direction and at the same speed. On the other hand, in the second arrangement—the magnet at rest and the disc revolving—the disc only could be the generator and the wire simply a neutral conductor. I cannot believe Nature to be so whimsical and erratic in her workings as this, and for reasons before stated I have no doubt whatever that in both of the above experiments the disc was the only generating conductor in the system.

Mr. Thompson again asks what the pivot arrangement proves. But he expects too much. I have endeavoured to prove that my theory is right rather than to show that Mr. Thompson is wrong; but in the latter case I must refer him to my previous letters to save repetition.

In his remarks on my proposed double-magnet experiment, published August 19th, Mr. Thompson fixes on an accidental feature of the system by attributing the current production to the wire bridge that electrically connects the two magnets; and in reproducing that diagram in his own letter he implies that the bridge would fully account for the current. True, there would be current from this cause, but it would be comparatively weak and opposed in direction to what I may term the legitimate current—that which is caused by the iron molecules of the extreme poles intersecting the lines of force. The output of the machine would be as the difference between these two opposed currents. However, a thin piece of brass could be arranged, in place of the wire and mercury cups, so as to hug and impinge on the two magnets respectively; and, better still, a solenoid could be used instead of a permanent magnet. The core would be divided at its equator, and, being of soft iron, the lines of force would be confined to it throughout its length, and the thin brush of brass would then undoubtedly be parallel to the external lines. Mr. Thompson asks me to explain how two discs mounted on the same axis can be made to develop current; and I must again refer him to my first letter, July 8th. In that a diagram of a machine is shown in which any number of discs are fixed to a common axis rotating in magnetically-closed solenoids. The only difference in its principle to the experimental apparatus that we have discussed is that the latter are so arranged as to make their external polarity evident by having lines of force exterior to themselves, and these lines as they lead from one pole to the other are cut by the rotating surface of the magnets—in fact, they are permanent magnets. But in my machine two or any even number of solenoids are placed parallel to each other—say, two—and the N of one is adjacent to S of the other. These two poles of opposite sign abut against an iron frame which magnetically closes the two poles, and at the same time supplies the bearings for the two shafts. By this means the lines are confined to the cores, and externally the machine would not develop any polarity other than that resulting from imperfect workmanship, or what may be termed practical or accidental defects.

Mr. Thompson notes that if a magnetised bar be moved bodily from one portion to another, it and its magnetic lines are inseparably connected and move together; and he asks why they should not be equally inseparable, and have an equal tendency to move together, when the same bar is moved by being rotated on its axis. Now, to consider this point it seems to me that we must first start from an incontrovertible fact. This. Iron has a greater affinity or a greater concentrative power for magnetism than any known substance, certainly more than the air space surrounding a bar magnet. I am impressed with the idea that so long as magnetism is confined to space or matter that is magnetically homogeneous it is too ethereal or too immaterial to be displaced. The space traversed by the movement of a magnetised bar from one point to another in air is not homogeneous because the magnet itself occupies part of that space. Therefore to expect the lines of force under such conditions to be stationary while the bar itself moved would be to expect magnetism to have the same affinity for air as for iron, inasmuch as to maintain its position the magnetism would have to leave the iron to take its place in air. It is this concentrative power or magnetic fixity of iron that prevents the separation. If the same magnetised bar is rotated on its axis the case is different. Its molecular construction being homogeneous, there is no tendency for the lines of force to be left in less magnetic space, because as one molecule, in rotating, advances, another of equal magnetic capacity is ready to take its place. A line of force, to speak honestly, is no respecter of molecules, so long as they are all alike.—Yours, &c.,

E. L. VOICE.

September 5th, 1887.

[It appears to us that the further discussion of this subject is unnecessary, both sides being most emphatic in "agreeing to differ."—ED. *E.*]

LITERATURE.

Electrical Distribution by Alternating Currents and Transformers. By RANKIN KENNEDY. (London: H. Alabaster, Gatehouse and Co.)

This is a little book of 60 pages, containing a reprint (with some additions) of a series of papers which originally appeared in our contemporary, the *Electrical Review*.

The subject of the distribution of electricity by alternating currents presents an alluring field for the display of mathematics, and hitherto its somewhat meagre literature has been generally more or less over the head of the average reader. This is a fault which cannot be charged against Mr. Kennedy. He tells us in the preface that "this pamphlet is issued simply as a collection of useful and interesting information gathered together during the past four or five years from experiments, practical applications, and specifications." The modest claims of the author are fully borne out by the contents of the book, as will be seen by the brief synopsis which we shall proceed to give.

Chapter I. deals briefly with the alternate current dynamo. The author mercifully refrains from inflicting upon us a disquisition upon the many obsolete types which are perfectly familiar to electricians, and is contented with cataloguing their titles. On the other hand, we are pleased to find a description of his own machine, which is not at present so widely known. In Mr. Kennedy's alternating current dynamo the armature consists of a cast-steel wheel, on the periphery of which insulated iron tape is wound to a depth of 8in. (in an armature of 4ft. diameter); slots are then planed out on both sides to contain the coils, which are wound up flush with the face of the armature. The field-magnets are of the Siemens type, with projecting poles on either side equal in number to the armature coils. Regulation for constant E.M.F. is effected by hand, but it is stated that for the larger sizes the resistance and self-induction of the armature are so low that no adjustment of the exciting current is required except in the neighbourhood of maximum output. On this question of self-induction Mr. Kennedy, at page 8, makes a slight slip, which should be corrected in a subsequent edition. He says "the magnetising effect of the current in the armature coils is proportional to the number of turns in the coils, and the amount of self-induction is proportional to the same thing." Self-induction is, however, proportionate to the *square* of the number of turns. For constant current regulation Mr. Kennedy adopts a plan which is analogous, or rather complementary, to that employed in the Zipernowski-Déri system for obtaining constant difference of potential. He connects the primary coil of a transformer as a shunt across the terminal of the machine, commutates the secondary current on the shaft of the dynamo, and employs this current to excite the field in conjunction with a separate constant-current exciter. We should be glad to be assured that this method gives a sufficiently good regulation in practice, because we understand that in the Zipernowski-Déri system it has been found necessary to supplement the converse arrangement by hand regulation.

Chapter II. deals with transformers, and contains a number of illustrations, with adequate descriptions of the several forms which had been devised up to the spring of the present year. As Mr. Kennedy justly observes, the transformer is one of the

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simplest pieces of electro-magnetic apparatus imaginable. Given a closed magnetic circuit with two separately insulated conductors wound thereon, the only constructive problem is to find the form which is cheapest to make and easiest to repair, combining the shortest magnetic circuit with the most ample ventilation. This last point is one on which Mr. Kennedy fails to lay so much stress as is desirable. The output of any given transformer is limited solely and simply by the rise of temperature in the coils and in the iron, hence ample ventilation is of the highest degree of importance. In certain transformers of recent design which we have had an opportunity of inspecting this fact has been fully recognised and has received most careful attention. Mr. Kennedy traces the history of the apparatus from the original solid iron ring of Faraday, and the open circuit induction coil of Rhumkorff, down to the modern types of Ferranti, Zipernowski Déri and Kennedy; giving due honour, of course, to Messrs. Gaulard and Gibbs, who, although somewhat unfortunate in the type of apparatus actually chosen, yet deserve the positive gratitude of the electrical world for so persistently forcing the claims of the system upon its (at first somewhat reluctant) attention. For small sizes Messrs. Dick and Kennedy make a transformer consisting of a Pacinotti ring with coils wound between the projecting teeth, the whole being then overwound (around the periphery) with iron tape. For larger sizes they prefer what Mr. Kennedy calls the "subdivided" type. This consists of a number of small transformers with rectangular iron cores stamped out of band iron, and so built up as to form one large cubical structure in which the several magnetic circuits are all closed. The advantage claimed for this form is that if any one pair of coils breaks down it can be immediately cut out of circuit without interfering with the remainder. On the other hand, as each primary coil has to have as many ampere-turns as if it did the whole of the work, it would appear that the construction entails some loss of economy.

The Ferranti transformer consists of two bundles of hoop iron, which are laid side by side through the same pair of coils, the ends being then doubled back outside so as to close the magnetic circuit. There is some tendency to heat in this form, but, as our readers are aware, it has met with great practical success at the Grosvenor Gallery installation.

Pages 24-27 deal with "the practical rules for the construction of transformers." Mr. Kennedy is, perhaps, scarcely so happy in his treatment of this part of the subject. His scheme does not include the mathematical investigation of any part of the problem—which, indeed, as yet has only been adequately treated by Kapp in his very beautiful graphical method. This being the case the author would perhaps have done better to have confined himself to pointing out the line of experiment which should be undertaken for the empirical determination of the proper windings. This is really all that his discussion amounts to, though by means of two so-called "laws" leading to certain "rules" a rather delusive appearance of precise theoretical treatment is imparted to the pages.

The first of Mr. Kennedy's "laws" runs as follows:—

"When no work is being done in the secondary circuit there should be no current in the primary circuit—that is, the counter pressure in the primary must be equal to the primary pressure or very nearly equal thereto."

This merely amounts to saying that the impedance of the primary coil *per se* should be sufficiently high to avoid waste of energy with open secondary circuit—which is, of course, quite true, although the statement seems scarcely entitled to the dignity of being termed a law.

The second law, which is similar in form, admits of being translated into the assertion that the core should preferably be worked upon the straight part of the saturation curve, which is also true. Then come Rules I. and II., amounting to this, that if we know already the counter E.M.F. generated per foot of wire in the primary, at a given number of alternations per second, having given also the desired number of volts at the terminals of the primary and secondary coils, then we can find the number of feet of wire in each coil by dividing in each case the total number of volts by the number of volts induced per foot of wire. This is again perfectly incontestable, only it must be confessed that the "if" is "rather a large order." Mr. Kennedy evidently perceives as much, for he recommends that a trial should be made upon the assumption of an induction of two volts per foot, which in his experience has generally been found to be an outside figure; wire can then be added to the primary until the impedance with open secondary circuit has reduced the current to an economical value; from this the turns on the secondary are found by the simple ratio of the volts. This is, no doubt, a good practical way of determining the windings, when once the vital question of the dimensions of the core has been settled. But upon the latter point Mr. Kennedy is content with the somewhat naïve remark that "data for calculating the size of the core may be obtained from dynamo builders," and he offers no remark on the bearing of this matter upon the "two volts per foot." It inevitably strikes one also that if Mr. Kennedy's instructions be too implicitly followed a core might easily be selected upon which we should afterwards find either a lack of room, or a waste of space in the aperture left for the coils, so that the method is really a purely experimental one.

Mr. Kapp's ingenious device of superposing the saturation curve of the iron upon the right line representing resultant magnetisation in his graphic construction (see *Industries*, April 15th, 1887) has already been placed before our readers (though not referred to by Mr. Kennedy), and it will interest them to know that a transformer designed by the aid of this method has been found in practice to conform with the predicted results to a remarkable degree of accuracy.

Chapter III. contains a detailed enumeration of the various patents which have been taken out dealing with systems of distribution in which transformers are employed. The earliest of these is that of M. Jablochkoff, in 1877, who proposed to make use of induction coils with vibrating interruptors for feeding his candles with a higher E.M.F. than that in the mains. We believe that the present owners of this patent contend that the claims cover the whole ground of the use of transformers for distribution, and entitle them to the exclusive use of the method. In November, 1878, a provisional specification (No. 4611) was filed by Messrs. E. Edwards and A. Normandy in which the use of alternating currents with induction coils was for the first time described. This patent was not proceeded with, but the appearance of the provisional specification having constituted publication, it is difficult to see how any "master-patent" of still later date can be established. The Gaulard-Gibbs specification is dated 1882, and follows closely on the lines of the 1878 specification above referred to.

In the following year (1883) Mr. Kennedy pointed out the advantages of the parallel system of connection as giving nearly perfect automatic self-regulation. Mr. Kennedy takes a pardonable pride in recalling this circumstance, and to his credit stands the fact that at the present time the whole of the successful installations of transformers in operation are working upon parallel mains. Nevertheless, we venture to think that it is somewhat rash to assert that the series connection is a total impossibility. In connection with the experiments of Mr. Kennedy in the year 1883 it should be observed that they were carried out with series-wound transformers (or, as Mr. Kennedy strenuously objects to this abbreviation, let us say wound-for-series-connection transformers). This circumstance led him at the time to overlook the possibility of using high tension in the mains with a parallel system, so that the letter in which he describes the self-regulation attainable by this means ends with these words: "But what about the size of the conductors in such a system? Prodigious!" This unfortunate remark does not appear to have been recalled by Mr. Kennedy until fully three years later, and in the meantime MM. Zipernowski-Déri and Blathy were enabled to claim the employment of the parallel system in a practical shape as an independent discovery of their own. The controversy between these gentlemen does not, however, appear to us to be one of any great importance either commercially or otherwise.

Mr. Kennedy's final development of his own particular distributing system involves the employment of a low potential dynamo, together with a pair of transformers of large size which raise the potential from 50 to 2,000 volts. The

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two secondary coils are then connected to a three-wire network of mains by which the current is distributed to the local transformers. In the diagram on page 43 the arrows showing the direction of the current in the external wires should on one half of the circuit have been turned the other way. It is evident that the main transformers must be so connected that they tend to send simultaneous currents in opposite directions through the middle wire.

Chapter IV. deals with measuring instruments for alternating currents. Dr. Fleming's disc galvanometer (first described in this journal, May 6th, 1887) is illustrated, together with Sir William Thomson's electrostatic voltmeter.

The last chapter, under the title of "Accessories," contains a recapitulation of the interesting experiments of Prof. Elihu Thomson on the repulsion exhibited by a closed circuit having a large time constant in an alternating field. Incidentally it is stated that there is no theoretical reason why alternating current motors should not be as good as continuous current motors—a conclusion which we fear is not as valid as could be wished. A synchronously running motor has certain very weak points, and the outlook for non-synchronous motors is, in view of the arguments set forth by Mr. Kapp (*see* paper in our present issue) somewhat blank.

Before concluding this notice it may be well to refer for a moment to the incorrect use of Oliver Heaviside's term "impedance," which occurs on page 6. It is there spoken of as synonymous with "counter-electromotive force." This is by no means the case. The impedance of a conductor is expressed by the formula

$$\sqrt{R^2 + (2\pi n L)^2},$$

where n is the number of alternations per second, and L the coefficient of self-induction. The impedance of a conductor without self-induction is therefore numerically equal to its resistance, and it would be proper to speak of the impedance of a 100-volt incandescent lamp as equivalent, say, to 160 ohms. The counter electromotive force, upon the other hand, generated by a sinusoidal alternating current of value I is measured by

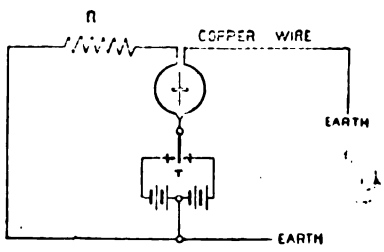
$$2\pi n L I.$$

In conclusion, we may be permitted to congratulate Mr. Kennedy on having produced the first connected account of a subject of such great and increasing importance.

ON THE COEFFICIENT OF SELF-INDUCTION IN TELEGRAPH WIRES.*

BY WILLIAM HENRY PREECE, F.R.S.

A considerable amount of attention has been devoted during the past two years to self-induction in apparatus, and various methods have been proposed and instruments devised to measure the coefficient L. These methods are of very little consequence to telegraphy, for electro-magnetic inertia (a much better term than self-induction for the general phenomena) has been entirely eliminated from high-speed telegraphic apparatus. It remains, however, an important factor in iron wires when they are used for high-speed telegraphy and for telephony.



In a paper read before the Royal Society on March 3rd of this year on the limiting distance of speech by telephone, I excluded electro-magnetic inertia as a factor in considering the time constant of copper wires, but as my measurements were not then complete I was unable to embody them in that paper, or to give the reason for not doing so.

The coefficient (L), which is a length, and throughout this paper indicates the number of units of 10^9 centimetres involved per mile, is very simply determined on circuits fitted up with Wheatstone apparatus on the duplex system, for the compensating coils (R) are double wound so as to be entirely free from any self-induction, while the line wire itself, if subject to it, will vary its effective resistance according to the well-known law dependent on the frequency of the periodic currents. When a Wheatstone transmitter (T) works at the rate of 50 words per minute, its frequency (p) is 20 per second, and when working at 250 words per minute its frequency is 100, so that at that speed $2\pi p$ or $m = 628$, and, therefore, $m^2 = 400{,}000$ approximately.

Now, since r the actual resistance per mile to steady currents becomes when these currents are periodic $(r^2 + L^2 m^2)^{\frac{1}{2}}$—sometimes called the throttling or spurious resistance—it will follow that L^2 must equal ·000025 to increase r by unity. But with copper wire of 270 miles long, delicately and sensitively balanced by steady currents, it has been impossible to observe any change whatever in the value of R when $m = 628$, and therefore L^2 must be less than $\frac{1}{2}\frac{1}{5}\frac{1}{0}$ of this amount, or less than ·00000001. L is therefore so small for copper that it may be neglected.

It must be remembered that the currents employed in high-speed telegraphy differ but very little in frequency from those of the dominant notes employed in telephony. We have worked from London to Bristol at the rate of 600 words per minute. This means a pitch of 240, which would give a value to m of 1,507. No difference whatever can be perceived, even at this high speed, in the character of the currents employed to distinguish them from those used for the transmission of slow signals through cables, or from those required for telephony.

I have spoken with telephones over 270×2, or 540, miles of copper wire with a clearness of articulation that is entirely opposed to the idea of the presence of any measureable magnitude of L.

It is, however, quite another matter with iron.

I have adopted several methods of measuring L in iron wire.

1. The duplex method.
2. The direct measurement of the time constant.
3. The limiting distance of speech.

1. The duplex method is the same as that used for copper wires.

$$R' = \sqrt{(R + L^2 m^2)}.$$

R is the actual total resistance to a steady current.

R′ is the observed total resistance due to frequency $\frac{m}{2\pi}$.

Two circuits of different resistances were taken, the one a metallic loop, 230 miles long, through Birmingham; the other a wire to Anglesey, 250 miles, using earth as return, each wire being of iron.

(*a*) . . . . . R = 3480ω.
R′ = 3560ω.
$m = 2\pi \times 100$.
L came out = ·00517.

(*b*) . . . . . R = 3000.
R′ = 3050.
$m = 2\pi \times 80$.
L came out = ·0048.

The mean of these two observations is ·00498.

2. The direct measurement of the time constant $\left(\frac{L}{R}\right)$ was taken with a chronograph similar to that described in my paper [*Proc.* Royal Society, March 3, 1887] on two wires erected on the same poles between Barnet and Newcastle, a distance of 261 miles, the one, No. 14 copper, and the other, No. 7½ iron.

The copper wire circuit—

Resistance = 2645ω.
Capacity = 7·44 microfarads.
Insulation = 47·6 megohms.

* Paper read before the British Association Meeting at Manchester, September, 1887.

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The iron wire circuit—

Resistance = 3433ω
Capacity = 8·13 microfarads
Insulation = 36·4 megohms.

The time constant was for—

Copper ·0044 second.
Iron ·00667 second.

If we neglect self-induction, then, the time constant being KR, or the product of the total capacity and the total resistance, we have KR for

Copper circuit = 19678
Iron circuit = 27910

and $$\frac{27910 \times \cdot0044}{19678} = \cdot00624'',$$

which should have been the time constant of the iron circuit if there had been no self-induction; but the time constant was ·00667, and the difference, ·00043, was that due to self-induction in the iron wire.

The actual length of iron wire is 255 miles, and its resistance 3068; hence

$$L = \cdot0051.$$

3. The limiting distance of speech test is given in my paper read at the Royal Society. I there pointed out that the distance to which we can speak varies in the ratio

$$\frac{\text{Iron}}{\text{Copper}} = \frac{10000}{12000},$$

and that this difference is due to the presence of electromagnetic inertia in the iron.

Now, if we assume that in the formula

$$x^2 = A/K\,r$$

r becomes $\sqrt{(r^2 + L^2m^2)}$.

Then it will be necessary for r, which is ordinarily 12ω per mile, to become 19ω to account for such a change, and the following table shows the different values of m and L, which will give this result:—

TABLE.

Values of $\sqrt{r^2 + L^2 m^2}$ for No. 7½ iron wire.

Values of m.	Values of L.					
	·0015	·002	·003	·004	·005	·0100
0	12,000	12,000	12,000	12,000	12,000	12,000
100	12,001	12,002	12,004	12,007	12,010	12,042
250	12,006	12,010	12,023	12,042	12,065	12,258
500	12,023	12,042	12,093	12,165	12,258	13,000
1,000	12,093	12,165	12,369	12,649	13,000	15,620
1,500	12,209	12,369	12,816	13,416	14,151	19,209
2,000	12,369	12,649	13,416	14,422	15,620	23,324
3,000	12,816	13,416	15,000	16,971	19,209	32,311
3,600	13,159	13,994	16 144	18,745	21,633	37,947
5,000	14,151	15,620	19,209	23,324	27,731	51,420
9,420	18,538	22,337	30,702	39,545	48,604	94,961

If we take L as ·005 it will follow that the value of m is 3,000, and therefore the dominant pitch in speech when transmitted by a telephone would be 480, but this point requires further inquiry, and I am now engaged in investigating it.

The value of L for iron wire is therefore by the

Duplex method ..... ·00498
Direct measurement ..... ·0051
Mean result ..... ·00504

I have assumed the value of L in copper to be 0; but let us, on the other hand, consider that it has some appreciable value. This value would reduce the ascertained value of L in iron when the two are directly compared. But the concordance of the results justifies the conclusion that the value of L in iron is ·005, and therefore inversely it justifies the assumption that L in copper approximately = 0; for if it did not, then we should see a difference when comparing copper and iron less than that observed by the direct measurement of iron alone.

Since we are dealing with circuits precisely similar in geometric form, the value of L will approximately be—

$$\frac{\text{Copper}}{\text{Iron}} = \frac{1}{\mu};$$

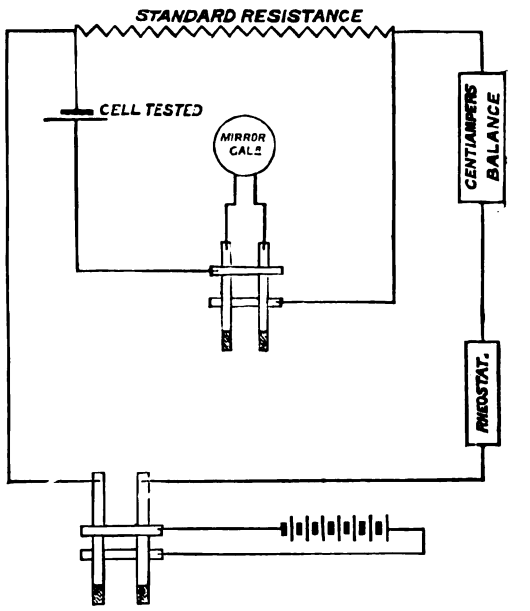
μ is usually taken for iron wire as equal to 300. If that be so, then L for copper, assuming that for iron to be ·00504, should be ·0000168, which is small enough to be neglected. But Prof. Ewing, F.R.S.,* has shown that for very soft iron wire strongly vibrated μ may be taken as high as 20,000, and that values of 1,000 and upwards are quite likely to be found in practice. If we take μ as 1,000 L for copper would be ·000005.

The virtual absence of electro-magnetic inertia in copper is leading to its extensive adoption for telegraphy, and no other wire should ever be used for telephony.

ON THE APPLICATION OF THE CENTI-AMPERE OR THE DECI-AMPERE BALANCE FOR THE MEASUREMENTS OF THE E.M.F. OF A SINGLE CELL †

BY SIR WILLIAM THOMSON, F.R.S.

For the purpose of measuring the E.M.F. of a single cell the centi-ampere or the deci-ampere balance is put in circuit with a battery of a different number of cells, a rheostat, and a standard resistance, in the manner shown in the diagram. The current measured by the balance is then varied by means of the rheostat until the difference of potential between the ends of the standard resistance is exactly equal to the potential of the cell. This equality is tested by placing the cell in series with a mirror galvanometer or a quadrant electrometer in a derived circuit, the ends of which are connected with the ends of the standard resistance, and observing whether any deflection is obtained by closing this circuit.



Suppose, for example, the standard resistance to be 10 ohms, and the current as indicated by the balance 0·108 ampere when no deflection is obtained on the mirror galvanometer by closing its circuit, the potential of the cell is 10 × ·108 or 1·08 volt. Proper precautions must of course be taken to eliminate thermo-electric or other disturbances in the circuit.

The quadrant electrometer may be used with advantage in

* *Phil. Trans.*, Part II., 1885, p. 568.

† Paper read before the British Association Meeting at Manchester, September, 1887.

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the derived circuit when it is important that no current should flow through the cell, but the mirror galvanometer has the advantage of much greater sensibility.

NEW ELECTRIC BALANCES.*

BY SIR WILLIAM THOMSON, F.R.S.

These balances are founded on the mutual forces, discovered by Ampère, between the fixed and movable portions of an electric circuit. The mutually influencing portions are usually circular rings. Circular coils or rings are fixed with their planes horizontal, to the ends of the beam of a balance, and are each acted on by two horizontal fixed rings placed one above and the other below the movable ring. Six grades of instruments are made, named centi-ampere, deci-ampere, ampere, deca-ampere, hecto-ampere, and kilo-ampere balance. The range of each balance is about 25. Thus, the centi-ampere balance will measure currents of from 2 to 50 centi-amperes, while the kilo-ampere balance will measure currents of from 100 to 2,500 amperes. Since the indications of the instrument depend on the mutual forces between two parts of an electric circuit of permanent form and relative position, they are not subject to the changes with time which are so troublesome in instruments the constants of which depend on the strength of permanent magnets.

The most important novelty in these balances is the connection between the movable and the fixed parts of the circuit. The beam of the balance is suspended by two flat ligaments made up of fine copper wires placed side by side. These ligaments serve instead of knife edges for the balance, and at the same time allow the current to pass into and out from the movable coils. The number of wires in each ligament varies from 20 in the centi-ampere to 900 in the kilo-ampere balance. The diameter of the wire is about one-tenth of a millimetre, and each centimetre breadth of the ligament contains about 100 wires.

The electric forces produced by the current are balanced by means of weights, which can be moved along a graduated scale by means of a self-relieving pendant. Two scales are provided, one a scale of equal divisions, the other a scale the numbers on which are double the square roots of the numbers on the scale of equal divisions. The square root scale allows the current to be read off directly to a sufficient degree of accuracy for most purposes. When high accuracy is required, the fine scale of equal divisions may be used, and the exact value of the current obtained from a table of doubled square roots supplied with the instrument.

An engine room voltmeter on a similar plan was described. It consists of a coil fixed to the end of a balance arm, suspended as above described, and acted on by one fixed coil placed below it. The distance apart of the two coils is indicated by means of a magnifying lever, and serves to indicate the difference of potential between the leads to which the instrument is connected. The coils of the instrument are of copper wire, and an external platinoid resistance of considerably greater amount is joined in circuit with it. The electrical forces are balanced by means of a weight placed in a trough fixed to the front of the movable coil, and weights suited to the temperatures 15deg., 20deg., 25deg., and 30deg. C., as indicated by a thermometer with its bulb in the centre of the coils, are provided.

Two other instruments were described, namely, a marine voltmeter suitable for measuring the potential of an electric circuit on board ship at sea, and a magneto-static current-meter suitable for a lamp counter.

In the marine voltmeter an oblate spheroid of soft iron is suspended in the centre of, and with its equatorial plane inclined at about 40deg. to, the axis of a small coil of fine wire by means of a stretched platinoid wire. When a current is passed through the coil the oblate of soft iron tends to set its equatorial plane parallel to the axis of the coil, and this tendency is resisted by the rigidity of the suspension wire.

The lamp counter is a tangent galvanometer with special provision for preventing damage to its silk fibre suspension, and for allowing the constant to be readily varied by the user to suit the lamps in his circuit.

* Paper read before the British Association Meeting at Manchester, September, 1887.

ON THE MAGNETISATION OF HADFIELD'S MANGANESE STEEL IN STRONG FIELDS.*

By Prof. J. A. EWING, F.R.S. (University College, Dundee), and Mr. WILLIAM LOW.

Messrs. Hadfield, of Sheffield, manufacture a steel containing about 12 per cent. of manganese and 0·8 per cent. of carbon, which possesses many remarkable qualities. Prominent amongst these, as the experiments of Hopkinson, Bottomley, and Barrett have shown, is a singular absence of magnetic susceptibility. Hopkinson, by applying a magnetic force, $\mathfrak{H}$, of 244 C.-G.-S. units to a specimen of this metal, produced a magnetic induction, $\mathfrak{B}$, of only 310 C.-G.-S. units; in other words, the permeability μ was 1·27 and the intensity of magnetisation $\mathfrak{I}$ was a little over five units. We are indebted to him for the suggestion that it would be interesting to apply to this metal the "isthmus" method of magnetisation (the results of which, as applied to wrought iron and cast iron, have been described in a former paper), with the view of seeing whether the magnetic resistance of manganese steel could be broken down by applying a very strong magnetising force.

Messrs. Hadfield were kind enough to supply a sample of the metal for experiment, out of which a bobbin was turned, with some difficulty, of a form resembling those used in testing wrought iron and cast iron, but with a wider central neck. The bobbin was magnetised by placing it between the pole-pieces of Prof. Tait's large magnet; and the induction within the neck, and also the field in the air immediately surrounding the neck, were measured in the usual way, by the help of two induction coils and by drawing the bobbin suddenly out from between the magnet poles. A large number of readings were taken, while the field magnet was excited with currents ranging from about 1 to 40 amperes. These gave values of the magnetic field (in the air immediately surrounding the central neck of the steel bobbin) ranging up to 5,200 C.-G.-S. units, and values of the induction $\mathfrak{B}$ within the neck ranging up to 7,700 C.-G.-S. units. To be more exact, these latter were the values of that part of the induction which disappeared when the metal was drawn out of the field, but the correction for residual magnetism was probably negligible. The ratio of induction to field had a nearly constant value when the field ranged from about 1,000 C.-G.-S. to 5,200 C.-G.-S.; the values of this ratio, calculated from the observations, fluctuate somewhat, but do not appear to undergo any progressive change. The mean value of $\frac{\mathfrak{B}}{\text{outside field}}$ is 1·45, a quantity which we may probably take without substantial error as the value of the permeability μ.

To test the influence of still stronger magnetic fields, a second series of experiments was made with a composite bobbin made up of a cylindrical shank, extending from end to end, of manganese steel, and conical pole-pieces of soft wrought iron forced on to the steel shank so as to leave only a short length of it (about 3 millimeters) bare in the middle. With a given current in the field magnets, this gave much higher values of the field and the induction in the central neck, because the wrought iron cones now substituted for the conical ends of the solid steel bobbin that had been formerly used gave an easier path for the lines of induction to converge to the central neck. The field now ranged up to values slightly exceeding 10,000 C.-G.-S. units, and the highest induction reached was about 15,000 C.-G.-S. units. In this series of experiments, as in the former series, the ratio of induction to field fluctuated irregularly; but its mean value was nearly identical with the former mean, namely 1·46. The intensity of magnetisation $\mathfrak{I}$ was forced up to values lying between 300 and 400 C.-G.-S.

The experiments make it clear that even under magnetic

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forces extending to 10,000 C.-G.-S. units the resistance which this manganese steel offers to being magnetised suffers no break-down in any way comparable to that which occurs in wrought iron, cast iron, or ordinary steel at a very early stage in the magnetising process. On the contrary, the permeability is approximately constant under large and small forces.

The conclusion has some practical interest. It has been suggested that this steel should be used for the bed-plates of dynamos and in other situations where a metal is wanted that will not divert the lines of induction from neighbouring spaces. In such cases the magnetic forces to which manganese steel would be subjected would certainly lie below the limit to which the force has been raised in these experiments. We may therefore conclude that in these uses of the material, it may be counted upon to exhibit a magnetic permeability only fractionally greater than that of copper, or brass, or air.

CLARKE'S TELEMETER SYSTEM.*

BY F. R. UPTON.

The problem of moving a secondary hand in synchronism with a primary hand by means of electricity has been long before electricians. Mr. Chas. L. Clarke, of New York, has given to the world one solution of this problem in the instruments which have been named the transmitter and receiver of the Telemeter System.

The need of a reliable electrical thermometer is very marked in the artificial refrigerating systems which are now so much used in the United States. From this necessity came this invention. Mr. Robert Hewitt, of New York, who was at the time engaged in the refrigerating business, after trying to make an electrical thermometer, and meeting with only partial success, applied to Clarke to aid him. The result I have the honour to bring before you in the instruments which are described as follows :—

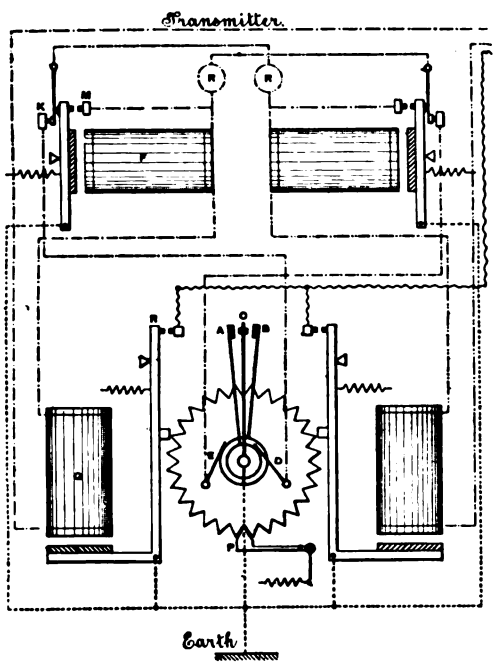
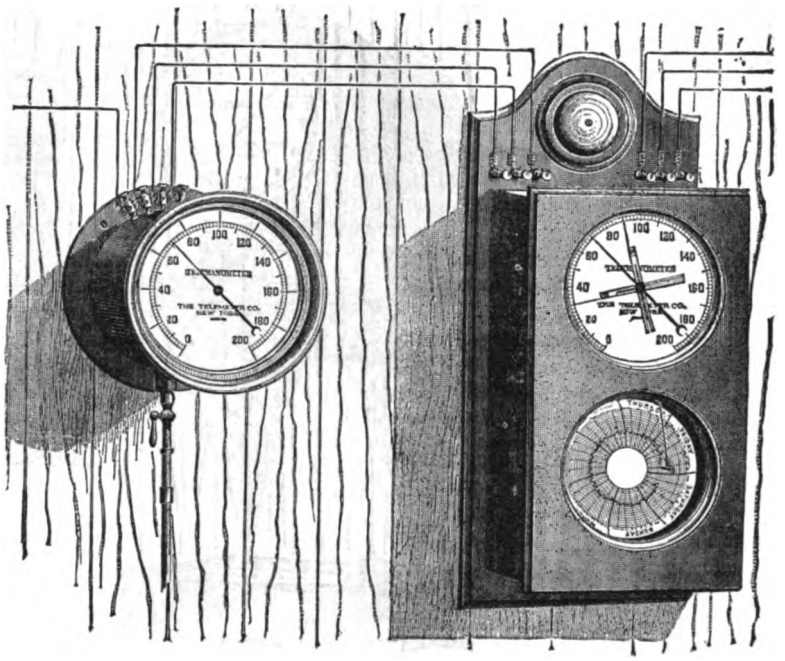


FIG. 1.

In the transmitter or primary instrument the toothed wheel and the contact arms A and B (Fig. 1) are supported by and revolve upon the same shaft. In line with this shaft is another shaft carrying the contact arm C. This shaft and contact arm are actuated, either by the spiral bi-metallic thermometer, the Bourdon tube of a steam gauge, or the pulley of a water gauge, as the case may be. Each of the contact arms A B is supported on a grooved hub insulated from the shaft, and electric contact is made by springs D E resting in the grooves of the insulated hubs. The dotted circuits in the transmitter represent the connections to the metallic frame of the instrument and to the return circuit or ground. In the receiver they represent the connections to the metallic frame and to the battery.

Assuming that the initial instrument is a thermometer, and that the temperature is rising, the thermometer, as the spiral opens, will move the contact arm C towards B until contact is made. The circuit will then be closed through the resistance spool R, magnets F G H. F is so adjusted and proportioned as to be the first in the series to work. As the armature of F is attracted it releases the flat spring K, which opens the circuit of the opposite side of the system. Contact is next made at M. This contact is a shunt of no resistance around the primary contact B C and the resistance R, substituting a firm contact in place of the delicate primary contact. After F the magnets G H operate, either simultaneously or one after the other, the time or order of their operations being of no consequence. The armature lever of G will first propel the toothed wheel by means of the pallet N. The wheel carries with it the contact arms A B, and the circuit at B C is opened. After the wheel has been propelled far enough for the centering pallet P to slip over the point of the next tooth, contact is made at R. When the armature lever of the magnet H has operated in the same manner contact is made at S, and the index hand with the wheel has been moved one space (say a degree) and in unison with the wheel and index hand of the transmitter. The contacts R S being completed the current is divided, a portion still flowing through the magnets F G H, the remainder through the circuit T and magnet U. The armature lever of U will, near the end of its stroke, hit the bell-crank lever V, throwing the horizontal end up, and thus breaking the circuit from the battery. Before the contact at V can be re-established all the magnets will demagnetise, the armature levers will be drawn by the retractile springs to their normal position. The circuit at B C has already opened by the forward motion of the transmitter wheel M R S, when the armature levers are drawn back and the contact at K is re-established. Last of all, contact V to the battery is made, and the instruments repeat the same series of operations when the temperature rises another unit.



Clarke's Telemeter.

If the temperature falls, the initial contact is made at A C; the circuit containing F G H is opened, the magnets on the other side propel the wheels and index hands; magnet U is connected to battery and circuit at V is opened. Among the mechanical details and methods by means of which the electric circuits are operated, special attention is directed to the following points :—No friction or opposition to the free motion of the initial instrument (thermometer, &c.) is made. It may

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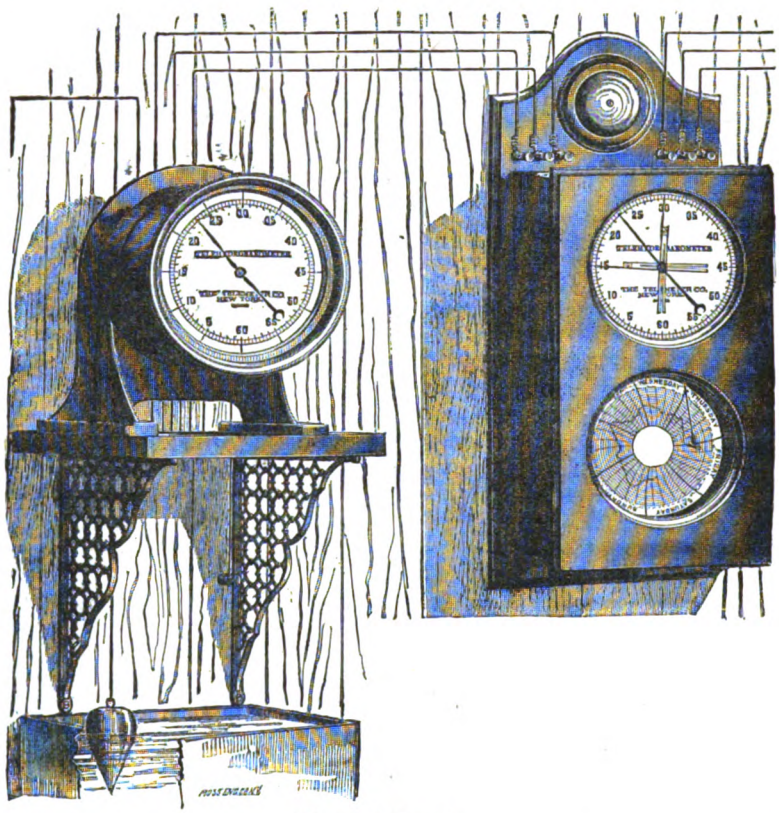
therefore be any delicate piece of mechanism or instrument which can impart motion to a hand (C).

The moment contact is made at B C, the circuit of the opposite side is opened at K. This prevents both sides of the system from acting simultaneously in case a violent blow or jar to the transmitter should cause C to oscillate rapidly, thereby making nearly simultaneous contact on both A and B. As each side opens the circuit of the other, one side must prevail. Without the circuit-opening device at K a rapid oscillation of C would bring both sides into action. The armature levers which move the toothed wheels would oppose each other, consequently the contacts at R and S could not be completed, U would not be connected to battery, the circuit at V would not be opened. The mechanism would remain in this position until the battery became exhausted. The next operation, or closing of circuit at M, not only substitutes a firm contact in place of a delicate contact, but allows the circuit at B C to be opened without spark, the circuit still remaining through M. Another point worthy of attention is that the magnet U being in an independent circuit completed by the final action of both instruments, the circuit is not opened until both instruments have completed the motion of the toothed wheels and index hands; therefore the index hands cannot get out of unison. Special attention has been given to the mechanical conformation of the wheels and pallets, making it impossible for any amount of battery power to cause the wheels to move more than one tooth for each movement of the armature lever. At every point of contact except A B C, one of the contact points is on a flat spring. This prevents any mechanical jar from opening contacts when once established. The springs are also bent, so that in making contact there is a slight rubbing motion. All the magnets have separate shunts connected to their terminals (not shown in diagrams) so that the discharge from the magnets shall pass through the shunts instead of taking place at V. The only spark at V is that due to breaking the battery current. It is exceedingly small and difficult to detect. One of these circuit breakers has been in use in a Time System, operating on the same principle as the instruments above described, and has, up to date, opened the circuit more than one and a-half million times and without any deterioration. Any injury which could occur from the spark is reduced to a minimum by the rapidity and completeness with which the contacts are separated. No spark occurs at contacts M R S, because these contacts do not separate until V is opened, leading directly to the battery.

To sum up, the instruments will work on an open circuit battery, and the wear on the points from electrical discharge has been so carefully looked after that the instruments will remain in adjustment for an indefinite period.

The mechanism which has been described can be used in many varieties of instruments. Mr. Clarke has adapted it to indicating the height of water in reservoirs, or the position of gas tanks; also for indicating steam or water pressure. There are also cases made for the thermometers to adapt it for the various industries in which it may be used.

The instrument is brought before you as a carefully worked out solution of the problem of indicating and recording at a distant point the movement of a revolving hand.



Clarke's Telemeter.

DISCUSSION.

Mr. FRANCIS: I have had an adaptation of these instruments two miles apart for indicating the height of water. I live in Lowell, Massachusetts, where a large number of people use water from mill ponds, and it is important to note the height of the water. One of these instruments has been in use and has answered very successfully. Previous to its employment it was necessary to send up a messenger every half hour from half a mile away. The instrument we put in two years ago in an experimental state, and at first there was a great deal of trouble with it, but for the past year it has answered perfectly. During the earthquake last year in the States, which took place between 9 and 10 o'clock, there was no indication in the neighbourhood excepting in that instrument, which showed that there was a little vibration in the mill pond just at the moment of the earthquake one hundred miles away.

Mr. G. KAPP asked whether the instrument indicated at one degree or stopped at any time.

Mr. UPTON: The movement in the instrument is about a degree and a half.

Mr. FRANCIS: In the instrument which I have, every quarter of an inch is indicated when a change takes place. In our instrument it is quarter-inch heights of water.

Mr. LAW said one important application of this instrument seemed to be the giving warning of the rising of the upper parts of rivers, so that the barriers or weirs might be prepared for passing the water off. An instrument of this sort was very much wanted to enable people to be prepared.

Mr. UPTON said that when the instrument was used to measure the height of water there was a contact which moved by a float. Then of course there was another instrument corresponding to the receiver having a large dial twice the diameter of that shown, giving a wavy line, which represented the quarters of inches. This was a very accurate method of measuring the height of water. One practical point in favour of this instrument was that it ran upon an ordinary Léclanché cell; it was an open circuit instrument, and took less power than was necessary to work an electric

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bell. He had known a battery used in connection with it to last for eighteen months.

The CHAIRMAN (Major-General Webber): I would ask you to bear in mind that in bringing this example of an important and interesting class of instruments to Europe, and producing it before this Association, Mr. Upton has, we must all think, earned from us a debt of gratitude, because the production of a practical working example must in all cases be far more interesting to a meeting such as this than is the case when the paper is sometimes brought before us in the absence of any particular illustration. There has been one paper in our list which has not been read, though doubtless dealing with a most interesting subject, because of the miscarriage in travelling of the instruments which were to have been used in explanation of the paper. We are most grateful to Mr. Upton, who is much better known in his own country than here, though he has been very often a visitor to this side of the Atlantic; but he is best known as being one of Mr. Edison's most tried and faithful assistants, and when the meeting knows that that is the case I am sure that they will more than ever appreciate the honour he has done us. One word more, and that is this, there will be no harm in closing the meeting of this section to-day by saying how much we appreciate the visitors who come to the meetings of this Association from the other side of the great ocean, and I have the pleasure and the honour of reminding you that the gentleman who spoke a few minutes ago and made those remarks on the subject of Mr. Upton's paper was Mr. Francis, a name which has been wafted to this little country as belonging to one to whom all engineers all over the world should feel very grateful for his works and munificence in connection with that branch of science. I propose, and I am sure you will all join with me by acclamation, a vote of thanks to Mr. Upton.

COMPENSATION OF ELECTRICAL MEASURING INSTRUMENTS.*

BY J. SWINBURNE.

Most instruments used for measuring electromotive forces depend on the electromagnetic effect of the current in a coil of high resistance. As the resistance of the coil varies with the temperature errors arise. Thus, a voltmeter wound with copper wire would be quite useless unless a temperature correction were made every time a reading was taken. Prof. Forbes has proposed to put a carbon resistance in series with a voltmeter, as the resistance of carbon falls as the temperature is increased. The idea of utilising this property of carbon is old, but instruments compensated with carbon have not come into use. Unless a carbon were in a vacuum its resistance would no doubt vary, as the carbon would absorb damp and gases.

The temperature error may be caused by the variations of temperature of the atmosphere surrounding the instruments, or by rise of temperature due to the heating of the coils when in use. The methods to be described in this paper consist of arrangements of wires of different temperature coefficients, so calculated that the reading of the instrument is not affected by reasonable variations in temperature. The electro-dynamometer wound as a voltmeter is the easiest instrument to compensate. Such an instrument consists of a large fixed coil, or pair of coils, with a small moving coil suspended and connected in series.

If the fixed and moving coils are wound with German silver wire, whose temperature coefficient is 0·044 per cent. per degree C., the readings will vary about 1 per cent. from winter to summer. 0·044 is the coefficient generally given in books, but German silver may have almost any temperature coefficient according to its composition. If an idle coil of copper wire is put in shunt to the moving coil, the current through the fixed coil will be divided between the moving coil and the copper resistance. As the temperature rises the current decreases if the electromotive force is kept constant; but as the resistance of the copper coil increases about ten times as fast as that of the German silver moving coil, the moving coil carries a larger share of the current, and the current in the moving coil can thus be made to increase so that the product of the current in the fixed and moving coils remains constant. Such a system does not give perfect compensation, but the error is of a higher order, and through ordinary ranges it is insignificant. This disposition compensates for the variations of temperature of the room, but not for rise of temperature due to the current itself. In a dynamometer-voltmeter this error is too small to be important, but there is no objection to winding the copper wire round the fixed coil so that it is at the same temperature. It may be doubled on itself so as to have no magnetic effect, or it may be wound backwards; but this gives rise to difficulties in the calculations. It would be of little use to work out examples, as the temperature coefficient of German silver varies with the sample. When the coefficent is known it is generally necessary to solve a cubic equation.

A voltmeter, such as a tangent galvanometer with a controlling magnet, may be compensated for room errors by putting a resistance of copper wire in shunt to it, and a German silver resistance in series; the resistances are so calculated that the current in the galvanometer coil is constant. This arrangement of course wastes a little power, but that is not generally a matter of any importance.

Another arrangement was suggested to the writer by Mr. Evershed, who was working with him. Instead of making the copper an idle coil, it may be wound backwards round the voltmeter, the exterior resistance being dispensed with. The magnetic effect is then the difference of the magnetic effects due to the German silver and copper wires. As the instrument heats the current in the German silver wire decreases, but the current in the copper wire decreases much faster, so that their difference remains practically constant. This arrangement is very suitable for low electromotive force voltmeters, but there are difficulties in the way of its use for high electromotive forces. Unless the copper wire is wound with the German silver, so that the two wires lie side by side, it is difficult or impossible to calculate the effects of the wires. If they are wound together, and the copper wire is then connected backwards, neighbouring wires have the full electromotive force to be measured upon them, and the insulation is apt to break down. In addition to this the copper wire has to be very small. Taking German silver as having ten times the specific resistance of copper by volume and $\frac{1}{10}$th of the temperature error, the ampere turns of copper wire would have to be $\frac{1}{10}$th of the ampere turns of German silver wire, so the diameter would have to be $\frac{1}{10}$th. In most cases this would demand a copper wire of from one to two millemitres diameter, which is too small for practical use.

Most Wheatstone bridges are wound with platinum silver wire, and when exact measurements are required, temperature corrections are made. Temperature corrections can be made unnecessary by winding the coils forming the adjustable resistance and the coils of the line side of the bridge with platinum silver, and the coils on the other side of the bridge with wire having twice the temperature coefficient. The coils with double temperature coefficients need not be made of any special alloy, as any temperature coefficient can be got by making the coil partly of platinum silver and partly of copper wire. The bridge still compensates if the galvanometer and battery change places.

The temperature error of a standard cell, such as the Clark, can be compensated. Such cells are arranged in shunt to a resistance which is in series with a larger resistance, which is generally adjustable, and varies from 30 to 60 times the resistance to which the cell is in shunt.

If the adjustable resistances are made of copper and German silver, so as to have higher temperature coefficients than the resistance in shunt to the standard cell, temperature errors of the cell can be eliminated. The adjustable resistance may be made up of ten coils of 1 ohm each and ten of 10 ohms each, 1·438 being in shunt to the cell, and 0·562 between the adjustable resistance and the 1·438 to make the resistance read in round numbers. The ten 10-ohm coils will thus have different proportions of copper and German silver, as their coefficients must be slightly different to compensate throughout the range.

There is another source of error which seems often to escape notice. If an electro-dynamometer is connected up as a watt meter for measuring small powers, such as that consumed in an incandescent lamp, either the pressure coil is in shunt to the lamp, and in series with the current coil, or it is in shunt to both the lamp and the current coil. In one case the current through the pressure coil measures the fall of potential, not only over the lamp but over the current coil also; in the other

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the current coil measures the current through the pressure coil as well as through the lamp. If all the lamps measured were of the same resistance this would not matter, as the instrument could be calibrated for that resistance, but the error in using the same voltmeter for 50 volt and 100-volt lamps is very considerable.

This error may be eliminated by a sort of differential winding. It is best to fix the current coil and make the pressure coil movable, as there is then less trouble in making the connections. A few turns of small wire, equal in number to those of the current coil, are wound backwards round it and put in series with the pressure coil. The pressure coil is then put in shunt to the lamp only. The portion of the current in the current coil which comes through the pressure coil then has its action neutralised by these backward turns carrying the same current.

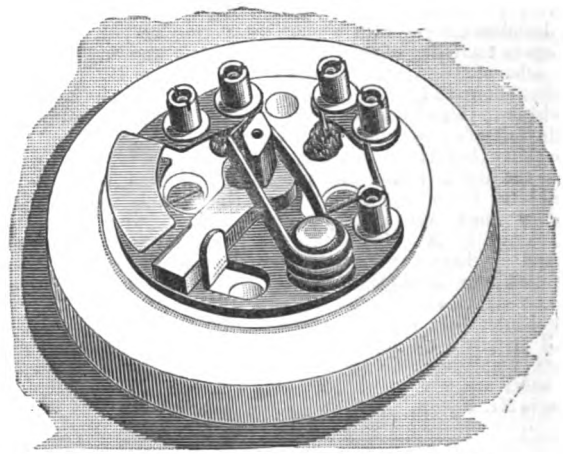
The same method may be applied to volt- and am-meters when used for such purposes as incandescent lamp measurement. If the voltmeter is in shunt to the lamp only, a few turns in series with it are wound backwards round the ammeter. If the voltmeter is in shunt to the lamp and the ammeter, a few turns of the main or ammeter circuit are wound backwards round the voltmeter coil.

AMERICAN EXPERIENCE OF UNDERGROUND WIRES.

During the Boston meeting of the American Electric Light Association some conversation took place on the subject of underground wires. The matter was brought forward by Mr. Leggett, of Detroit, who appealed to the association for advice under the difficulty in which they were placed at Detroit by the order of City Council to place all wires underground. Detroit, as our readers will probably recollect, is lit by the "tower" system, and the length of wire employed exceeds 400 miles. "We have invested," said Mr. Leggett, "nearly half a million of dollars in our plant, and you can readily see that we are driven to an extremity. I must confess that after all our investigations in this matter we are as yet entirely undecided to know what to do. We want to know whether we are obliged to take one of a number of things, each of which is experimental, or whether there is some system which some member of this association can say he has found to be expedient and practicable throughout." Mr. De Camp said that in Philadelphia the city electrical department about a year and a half ago made an appropriation of $5,000 to put down a line about one mile long. "A lead-cased cable was laid, well insulated, put in a trough which was filled up with residuum of petroleum. That carried 12 lights of 30 volts each, which was the extent of that particular line. The cable is working fairly well, but from various causes has had more or less grounds on it—very many more than the overhead circuit. Additional experience was recently had at South-street, where there was a circuit of one mile put in. The first circuit put in was taken up for some reason or other, it being a failure. The cable, which is there to-day, is a good one, but the superintendent tells me that the grounds are so numerous that he hardly knows where he commences to pick them out; and there they are to-day in that condition. Whether it is the fault of the cable or of the conduit or of the work done I do not know. That, however, has brought us to this conclusion, that we have got to replace all of that before we shall be justified in running lines over such a circuit." Mr. Brown said that he had had about eighteen months' experience with underground work in Chicago. "We have there the Dorsett conduit, and are troubled greatly with gas, and have had two or three explosions, although they have not caused much damage. We find that the principal trouble with the conduit is at the joint. We think if a perfectly tight conduit joint could be made that we would not be so much troubled with gas, and even water that leaks in. The newest conduit which we know of in Chicago is the Hurlburt conduit, which has a flexible joint. It has been on the market but a short time, and I do not know that any of it has been laid. But it seems to me that it would carry out the expectations entertained regarding it from the fact that the joint is flexible. We have manholes at an average distance of 400ft. apart, and between the manholes we find that the conduit sags after it has been laid any length of time from the pressure from above—the street traffic. We have some 60 or 70 miles of wire under ground." Mr. Powers, of Troy, expressed a very strong opinion that it was not possible to place electric light wires underground in the present state of the art, especially where lights are spread over a large area. Mr. Law remarked that in Philadelphia they had also had a good deal of trouble from gas leaking into the conduits.

DORMAN AND SMITH'S PORCELAIN SWITCH AND SAFETY FUSES.

Messrs. Dorman and Smith, of Manchester, send for our inspection a specimen of one of their combined switch and safety fuses, mounted and enclosed in porcelain. The interior of the switch is illustrated in the accompanying engraving. It will be seen that it



is fitted with a strong spring throw-off, and has good rubbing contact. In the smaller sizes a porcelain thumb-screw handle is attached to the central pivot (this is not seen in the figure), but in the larger sizes Mr. J. H. Holmes's device of a loose handle is adopted. In this arrangement the hole in the turnkey is made larger than the diamond over which it fits, consequently as soon as the contact piece comes under the influence of the spring, the diamond turns loosely in the key and a quick throw-off is secured irrespective of the speed at which the handle is moved. With the thumb-screw in the small sizes this is not necessary, because the handle easily twists in the fingers. We are informed that large numbers of these switches have recently been supplied for ship-lighting.

We are glad to note the rapidly extending use of non-inflammable switch and fuse blocks for installations of all kinds.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 14.		Business Done Week Ending Sept. 14. Highest.		Lowest.	
Anglo-American	37,	38	.....	37½	.....	—
Do. Preferred	59½,	60½	.....	60	.....	59½
Do. Deferred	14,	15	.....	14½	.....	14½
Brazilian Submarine	11½,	11⅝	.....	11½	.....	11 1-16
Cuba	11¾,	12¼	.....	12¼	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅞,	3¼	.....	—	.....	—
Do. Preference	7½,	8½	.....	—	.....	—
Direct United States Cable	8⅝,	9½	.....	8⅝	.....	8 13-16
Eastern Telegraph	10⅜,	11½	.....	11½	.....	10⅝
Do. 6 per Cent. Preference	14,	14½	.....	14⅝	.....	14
Do. 5 per Cent. Debentures, 1899	106,	109	.....	—	.....	—
Eastern Extension	11⅞,	12	.....	12	.....	11⅞
German Union	10½,	11	.....	10 13-16	.....	10⅞
Globe Telegraph and Trust	5⅝,	5⅝	.....	5⅝	.....	5 7-16
Do. Preference	13½,	13⅝	.....	13⅝	.....	13 1-16
Great Northern	13½,	14	.....	13 15-16	.....	13 3-16
Indo-European	35,	37	.....	—	.....	—
Reuter's	7½,	8	.....	8	.....	—
Submarine	170,	180	.....	—	.....	—
West India and Panama	⅝,	⅞	.....	—	.....	—
Do. 1st Preference	9,	9½	.....	9 7-16	.....	—
Western Brazilian	7⅜,	8	.....	8	.....	7 13-16
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	101,	104	.....	—	.....	— xd.

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	.....	⅞	.....	—
Oriental	5-16	7-16	.....	—	.....	—
United Telephone	12½,	12¾	.....	12⅝	.....	12⅝
United River Plate	4½,	5	.....	—	.....	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1½,	2	.....	1½	.....	—
Do. (fully paid)	3,	4	.....	—	.....	—
Swan	1½,	1½	.....	1½	.....	1⅝
Maxim Weston	⅛,	¼	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	.....	37½	.....	—
India Rubber, Gutta Percha, and Telegraph Works	22,	23	.....	22¾	.....	22¾

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NOTES.

THE CHARGE OF ALTERING TELEGRAMS.—Harry Wilkes, the telegraph clerk who is charged with altering racing messages, has been committed for trial.

EDISON'S PYRO-MAGNETIC DYNAMO.—This machine will be on view in New York at the Exhibition of the Electrical Society, which opens next week in that city.

THEATRE LIGHTING IN LONDON.—We hear that five theatres in the West-end are about to be supplied with electric light by means of Ferranti transformers from the central station at the Grosvenor Gallery.

THE ITALIAN TELEGRAPH SYSTEM.—There are now 2,145 telegraph offices open in Italy, and during the first three months of the present year the number of messages dealt with amounted to 1,847,781, of which 170,469 were foreign.

ELECTRIC CARS IN LISBON.—The Portuguese papers report that Julien's system of electric traction is about to be introduced for the public service by the Companhia Corris de Ferro of Lisbon. Experimental trips were to be made last week.

THE LIGHTING OF OPORTO.—The Portuguese paper, *O'Diario Populas*, says that the Executive Committee of the Municipality of Oporto has been authorised to denounce the contract with the gas company, which will terminate in 1889, and to receive proposals for lighting the city by other means.

PARIS.—It is stated that Messrs. Rothschild, Marcel Deprez, and Gerald are working out a scheme for providing electric light for "the whole of Paris," "the mathematicians of the establishment" having demonstrated, we are told, that such a scheme will prove more economical than that of isolated installations.

LECTURE BY DR. FLEMING.—At the meeting of the Iron and Steel Institute at Manchester, Dr. J. A. Fleming delivered an interesting lecture on "Electric Lighting in Factories." The lecture attracted a good deal of attention among the members of the institute, and it may be hoped will be fruitful in results.

WHAT DOES THIS MEAN?—We quote the following sentence from a paragraph in the *Electrical World* of New York. The italics are our own:—"Such a city as London ought to present a magnificent field for the utilisation of the electric motor, which will certainly very soon come to the front there, *probably in some degree through American enterprise.*"

THE CITY OF LONDON COLLEGE.—The fortieth session of the City of London College, White-street, Moorfields, E.C., commences on Monday, October 3rd. The scientific work of this institution, although of an elementary character, is in excellent hands, and the evening classes in electricity and magnetism probably form as good an introduction to the subject as can be obtained.

BATS.—A new industry has sprung up at one of the American towns in catching bats by electric light. Every night men may be seen around the arc lights in the quieter streets armed with a kind of large butterfly net, in which the bats, dazzled by the light, are easily caught. The market value of a bat is at present about 5 cents. We do not, however, know what is done with them—unless they are served up as game-pie.

ATTEMPTED STORAGE OF ENERGY DERIVED FROM WIND.—The Duc de Feltre has succeeded in persuading the French Government to allow him to try to supply the electric lights at La Héve Lighthouse by means of a battery of accumulators which are to be charged by wind power. The windmill is to drive a dynamo which is to charge the accumulators. The success of the experiment is, we need hardly say, extremely doubtful.

CABLE EXTENSION.—The ss. "Scotia" left Greenwich on the 19th inst., having on board 1,500 nautical miles of cable, to lay a duplicate cable between Gibraltar and Malta, and an extension from Malta to Zante. Mr. Lucas is in charge of the laying on the part of the Telegraph Construction and Maintenance Company, and Messrs. Forde and Taylor and staff represent the Eastern Telegraph Company. This will give the latter company another line between England and Malta.

THE SCIENCE AND ARTS DEPARTMENT.—At the examination in magnetism and electricity, held on the 11th May, 1887, 14,001 candidates presented themselves; of these 12,257 came up in the elementary stage, 1,683 in the advanced stage, and 61 in honours. The results were as follows:—In the elementary stage 1,041 obtained a first class, 5,907 a second class, and 5,309 failed. In the advanced stage 237 obtained a first class, 744 a second class, and 702 failed. In honours no candidate obtained a first class, 5 obtained a second class, and 56 failed.

CATAGRAPHY.—According to an American paper a farmer somewhere out west was recently annoyed by the squalling of some cats in the back yard during a thunderstorm. Going out to quiet them a blinding flash lit up the heavens—the cats were seen no more, but upon the forehead of the unhappy man their portraits had been indelibly impressed. Such stories have been recorded before, and need not necessarily be untrue. In a museum at Washington there is a brass tray upon which the face of a young girl has been stamped by a lightning flash. This occurred about twelve months ago, and we gave the particulars at the time.

AMERICAN PATENT LAW: IMPORTANT DECISION.—According to American patent law, if a patent is taken out in any foreign country *prior* to the granting of a United States patent for the same invention, then the United States patent, at whatever date it may be subsequently obtained, expires at the same period as the earliest of such foreign patents. In a case which recently came before the American Courts it has, however, been decided that for the purpose of the clause above referred to, the date of an English patent is not that of the filing of the provisional specification, but that upon which the patent is sealed. This decision is therefore very favourable for English inventors.

MR. TROTTER'S SYSTEM OF REGULATION.—We mentioned last week that Edison had described a method of obtaining regulations for constant current by a method similar to that described by Mr. Trotter in his recent paper. On further examination, however, we think it only fair to state that it does not appear that Edison had at all clearly conceived the special feature of Mr. Trotter's method, which consists in varying the magnetic susceptibility of the second half of the exciting circuit by varying the exciting power instead of directly varying the magnetic resistance. Edison's ideas branched out in various directions, but it is not at all clear that he had perceived the advantages of the method now described.

EARLY SUGGESTIONS FOR ELECTRIC WELDING.—In the *Manchester Memoirs*, Vol., XIV. p. 49, Joule has a note "On the Fusion of Metals by Voltaic Electricity," in which he speaks of the advantages of electric welding if current could be supplied economically, and describes some experiments made with iron wire. Joule calculated that, using a primary

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battery, the quantity of zinc consumed in the voltaic process is nearly equal to that of the iron to be melted. He concluded by pointing out that "it would be possible to effect the same object in a more economical manner by availing ourselves of the use of the magneto-electrical machine, and that 5,000 grains of coal used in this way would suffice for the fusion of one pound of iron."

VACANCY FOR ELECTRICIAN IN THE COLONY OF BRITISH GUIANA.—The following notice appears in the *Post Office Circular* of September 20:—"A vacancy for an electrician has occurred in the Colony of British Guiana. Salary £350, by £10 per annum to £400. Deduction of 4 per cent. from salary towards widows' and orphans' fund. Pension of one-fiftieth of salary for each year of service after ten years' service and fifty-five years of age. When travelling on duty in the colony the electrician is paid actual travelling expenses, and a personal allowance of 16s. 8d. a day when absent from fixed residence. At the request of the Secretary of State for the Colonies applications for this situation are invited. The officer selected will be required to take technical charge of the Government land lines and cables, under the superintendence of the Postmaster-General of the Colony."

NEW SPANISH TELEGRAPH SYSTEM.—It is stated by the Madrid paper *El Dia* that the system of duplex telegraphy invented by the Spanish telegraph official, Señor Perez Santano, has been definitely installed between Madrid and Valencia. According to the same paper, Señor Santano is represented by the consultative Board of Telegraphs to have added a "brilliant page to the history of telegraphy by his invention." Another journal, *Las Ocurrencias*, in dwelling upon the advantages of the system, says that in a line of 360 kilometres, which is the length of the Valencia line, with a capacity of 1·50 microfarad and an approximate resistance of 4,000 ohms, the duplex system works without condenser or compensation of any description. "And if to this," says the journal in question, "be added the fact that the Morse system can be converted into 'Santano' without incurring the expense of a single centime, it will be recognised how transcendental is the service rendered by Señor Perez Santano to his country." Experiments were shortly to be made upon the copper lines between Madrid and the French frontier.

ATLANTIC CABLE RATES.—The following circular letter, not wholly unexpected (says the *Electrical World*), was issued on September 1 from the executive offices at No. 40, Wall-street, of the Commercial Cable Company (Mackay-Bennett cables):—"To the Patrons of the Commercial Cable Company: On and after September 15, 1887, our tariff will be 12 cents per word to Great Britain, Ireland, and France, and 15 cents per word to Germany. We have in justice to our patrons decided upon this reduction in order to give them the benefit of the lowest rates during the time the tariff war may last. We sincerely thank our friends for the hearty support they have so steadily given us, and believe the cabling public will see it to be to their interest to favour the Commercial Company with a continuance of their patronage.—George G. Ward, Secretary and General Manager." Vice-President Hector De Castro, of the Commercial Cable Company, said that the reduction had been made from 25 cents a word not because of lack of business, for the patrons of the company had stood by it nobly, but simply because it was the fair thing to do.

THE GENERAL ELECTRIC APPARATUS COMPANY'S CATALOGUES.—The General Electric Apparatus Company send copies of a new edition of their illustrated catalogues. The electric bell catalogue contains a long list of bells, indicators, batteries, and accessories, together with a very complete set of instructions and diagrams showing the different methods of making the connections. This should be especially useful to amateurs and others who wish to connect up their own bells. A second catalogue of the same firm is devoted to "electric lighting plant and material," and contains a list of engines, dynamos, accumulators, transformers, switches, cut-outs, main and branch leads, arc and incandescent lamps, holders, fittings, ammeters, voltmeters, glass-ware, and wood-casing, &c., &c., &c. This enumeration will sufficiently indicate the exhaustive character of the list, and with respect more particularly to certain of the minor appointments, such as glass-ware and fittings, it may be remarked that the company has been successful in introducing some novel and improved types. The catalogue will be of service to all interested in electric lighting.

ELECTRIC LIGHTING OF THE MANCHESTER THEATRES.—A correspondent of the *Manchester Guardian* writes as follows:—"Less than two years ago we had two theatres—the Royal and the Comedy—in Manchester lighted by electricity. The electric plant was in an adjoining warehouse, and the installations appeared to give every satisfaction. This has been discontinued and lighting with gas resumed. Surely now that we have received so terrible a warning against the use of gas in theatres the managers will see their way to resuming the electric illumination, as many people are deterred from entering the buildings by the manifest danger, in spite of the great attractions now offered." The installation referred to was carried out by the Manchester-Edison Company, current being supplied from a central station at a rate equivalent to gas at the Manchester price, which is, we believe, about 2*s.* 8d. per 1,000 cubic feet. The installation was entirely successful; but naturally it was not a paying speculation, and failing to obtain a better price the company were no doubt well advised in discontinuing the service, which they did in April or May of the present year.

TENDERS REQUIRED FOR TELEGRAPH POLES AND CREOSOTING.—The Postmaster-General is advertising for tenders for the supply of 7,710 red fir telegraph poles to be delivered in London, and 16,955 to be delivered at Northumberland Dock (River Tyne) or West Hartlepool. The poles to be felled between 1st November, 1887, and 28th February, 1888, and to be delivered during the following summer. Tenders are also invited for creosoting the above-mentioned poles with either 8lb. or 10lb. of creosote to the cubic foot, as may be decided hereafter. Tenders may be submitted for either (A) the supply of the poles; (B) both the supply and creosoting; or (C) the creosoting only; but if (B) be tendered for, tenders for (A) and (C) are also requested. Any person tendering, who has not previously supplied the Postmaster-General with poles, must submit thin butt sections from not less than three different poles, to show the quality of timber offered. Forms of tender, containing all particulars, may be obtained on application, either personally or by letter, to Mr. W. H. Winter, controller of stores, Telegraph-street, London, E.C. Tenders will be received by noon on 24th October.

POST OFFICE TELEGRAPHS.—In his thirty-third annual report for the year 1886-7 the Postmaster-General remarks, with reference to the telegraph service:—"The first complete financial year during which the reduced rates for inland telegrams were in operation expired on the 31st of March, and it is interesting to note the effect upon the number of messages and upon the revenue. Separating the ordi-

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nary inland messages sent in that period from railway, press, official, and foreign telegrams, which are not affected by the reduced rate, and of which there were over ten millions, it appears that the number of messages despatched was 40,137,175 in 1886-87, compared with a total of 30,087,869 in 1885-86, and that the revenue produced was £1,354,879, as compared £1,277,606 in the previous year, showing a growth of over ten millions, or 33 per cent. in the number of messages, and over £77,000, or 6 per cent. in the revenue. The London local messages alone show an increase of 50 per cent., the total number being about 3,800,000. The expenses of this service, however, far exceed the receipts, and the deficit, after including the interest payable for the capital borrowed, amounted to £469,840."

LIGHTNING CONDUCTORS.—Dr. J. A. Fleming writes as follows to *The Times* on the subject of lightning conductors:—"May I be permitted to add one word to what has been already said by your scientific correspondents in caution to those having structures under their care not already properly protected from lightning? Not only is it necessary to have a properly fitted conductor or system of conductors to every valuable building, but it is above all things necessary to have a periodical electrical test applied to the conductor in order to ascertain if the earth plate is making 'good earth.' The proper manner of doing this is to run a second isolated cable parallel to the conductor and making contact with it near the top. This testing cable should have a separate earth plate. A simple electrical test, applied easily, will then enable an observer to state whether that conductor is an efficient lightning protector, or only an additional source of danger. I venture to think that of our English cathedrals and public buildings having more or less imperfect lightning protection, not one in a dozen is ever inspected, tested, or certified to as secure by a competent authority. Every lightning conductor should be properly tested once a year at least, and a certificate of the test furnished to those responsible for the building."

SOME BELGIAN TENDERS.—For the electric lighting of the military hospital at Ixelles, near Brussels, the following tenders were received:—

	Francs.
Société Electricité et Hydraulique of Charleroi.	67,200
Société Bouckaert et Cie. of Brussels	68,200
Société Phœnix-Edison of Ghent	68,300
Société Industrielle d'Electricité of Brussels ...	73,000
Société L'Electrique of Brussels	74,100

The first-named tender (which has been accepted) includes the superintendence of the installation during the first twelve months.—A contract has been signed for lighting the railway station of Meirelbeke, Ghent, by Messrs. Bouckaert and Co., who represent the German firm of Schuckert and Co. Twenty-four arcs of the Krisik type of 600 candle-power are to be used. The installation is to be worked by the contractors under the following tariff:—0fr. 54c. per lamp-hour for the first 3,000 lamp-hours; 0fr. 48c. for the succeeding 500 lamp-hours, and 0fr. 40c. for the remainder.—Our Brussels correspondent informs us that a good deal of work is being carried out in Brussels and the neighbourhood. The premises of Messrs. Hirsch, in the Rue Neuve, are being supplied with 300 incandescent and 40 to 50 arc lamps. A steam engine of 80 horse-power is provided, driving two dynamos delivering 150 amperes at 100 volts.

TELEPHONIC COMMUNICATION IN MID-LOTHIAN.—The Mid-Lothian County Road Board have, it appears, decided that "with the view of commencing a system of telephonic communication throughout the county" permission shall be granted to the National Telephone Company "to place certain lines of communication through the eastern part of the county, with two call boxes," as also "a short line from the western confines of the company to the Oakbank Oil Company's Works, with a subordinate call box at Mid-Calder." Mr. R. A. Macfie, of Dreghorn, has issued a printed statement to the members of the County Road Trust (whose confirmation he understands is required in the matter), in the course of which he indicates certain objections to the above decision of the Board as it stands, and suggests that the question should be reconsidered. He specifically complains that they "have left the whole areas of the water of Leith above the city and the Upper Esk, and such important and populous places as Corstorphine, Juniper Green, Lasswade, Liberton, Loanhead, Midcalder, Pathhead, Penicuick, and Slateford unprovided, and have also made it very improbable that any other company will enter the field, thus constituting practically a very valuable unlimited monopoly." Decidedly we are getting on (in Scotland at least) when Juniper Green has a grievance in the lack of telephones.

CHINESE TELEGRAPHS.—It is stated that the very first operation of the American syndicate which has obtained concessions from the Chinese Government will be the establishment of long-distance telephone lines between all the chief cities of the country. It is known that a considerable number of land lines already exist in China, and of late years have been rapidly extended, chiefly under the supervision of some Danish engineers. The first line was that between Hong Kong and Shanghai—chiefly submarine—which was opened in 1873. The Chinese having no alphabet, it is the rule to translate native messages into some European language and retranslate at the other end. Upon the land lines, however, a mercantile code, containing 7,000 terms in common use, has been compiled by the Chinese authorities, the words being indicated by a number placed opposite each character. This system has proved itself fully competent to deal with the present amount of traffic, but it is obvious that with the awakening of the country, which seems now to have set in in earnest, it will have to give way to some more rapid process. Unless the Chinese follow the example of their neighbours the Japs, and learn English wholesale, it is probable that the telephone, or perhaps the writing telegraph, will prove the most rapid means of communication available. Even at the most reckless rate of progress it will be some years before they feel the need of a Wheatstone automatic at 450 words per minute.

SOME PROPHETIC ELECTRIC LIGHT FIGURES.—Our monthly contemporary, the New York *Electrician*, has the following cheerful forecast of the future of electric lighting in the States:—"Now that modern improvements in the methods of distributing electricity for incandescent lighting have rendered it practicable to establish and maintain central station plants at a profit, even in towns of not more than 4,000 inhabitants, it has become possible to ascertain with some approach to accuracy the dimensions of the field which is open to be occupied by this incomparable illuminant. Experience shows that when house-to-house lighting has been thoroughly worked up in any town, the capacity of the central station plant will need to be equal to an average of about one 16 candle-power lamp for each inhabitant. According to the census of 1880, of the 50,000,000 inhabitants of the United States, 13,000,000 or 26 per cent., resided in 580 towns and cities having a population in excess of 4,000 each. At the normal rate of increase we shall have, in five years from the present writing, a population of nearly 70,000,000, of whom some 18,000,000 will be gathered within the limits of towns

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of 4,000 inhabitants and upwards. Each of these individuals will represent one incandescent lamp and the necessary power for operating the same. Even after deducting the lamps which have already been installed, there will be required a total output of more than 11,000 lamps and over 1,000 horse-power each of steam-engines, boilers, and dynamos, every working day for the next five years to supply the demand which from all present appearances will inevitably arise. This is entirely aside from the additional number of lamps which will be required for renewals—itself an enormous item. The change from gas to electricity which is now going on in connection with domestic lighting will be not a little accelerated by the action of the gas companies, who are everywhere evincing an increasing disposition to take up electric lighting themselves; and a very sagacious policy it is, too, in view of the present outlook for gas illumination."

BERLINER'S "ELECTRIC FURNACE GENERATOR."—The *Electrical World* of the 10th inst. contains a letter from a solicitor in America enclosing a copy of a specification filed by M. Emile Berliner, on June 18th, 1885, describing an "electric furnace generator," which is in principle substantially the same invention as Edison's pyro-magnetic dynamo. The letter contains the following passage:—"You will notice that the numerous suggestions of modifications which appear in the specification contain the germs of valuable improvements upon the original apparatus, and those who know the untiring productiveness of Mr. Berliner will at once understand that these germs were not allowed to die for want of nourishment. Mr. Berliner freely communicated his original ideas to other electricians at an early period; he invited them to join in his work, but they declined, and, in one remarkable instance, at least, upon the ground that the invention was completed, and that there was no room left for the elaboration of the original idea. . . ." The writer is careful to exonerate Edison from a knowledge of these facts. The apparatus devised by M. Berliner is constructed as follows: A magnetised steel cylinder with a some what narrow bore is surrounded with a coil of wire insulated with asbestos or some other fire-proof substance. The cylinder is set upright over a furnace, and its lower end is closed by an iron plate, against which the heated gases play upon the lower side. To the upper end of the hollow magnet a flexible tube is attached, with which a pair of bellows is connected. Each time the bellows is compressed the current of cool air increases the magnetic susceptibility of the iron plate which acts as an armature, and a current of electricity is consequently induced in the coil. The specification concludes in the following terms:—"The current thereby produced might be utilised to charge another coil surrounding the magnet and re-enforce the magnetic field; and in that case the magnet might be substituted by a tubular core of iron; the bellows might be dispensed with, and a constant source of compressed air might be employed, regulated by suitable mechanism to supply the air puffs to be directed against armature K, or even pieces of cold metal might be made to approach the armature at intervals, and cool it by contact with the same; or by absorption and radiation; or a series of coils and magnets might be placed towards one larger armature disc forming a common armature, heated by one furnace. All these ideas can be brought to bear on the subject whenever time offers itself to experiment, which is the most effective modus. For the present, I claim: The combination with the magnetic field and a conductor situated therein, of a piece of iron which is alternately heated and cooled, thereby producing electricity, substantially as described." It is evident that the weak point of this arrangement, in comparison with Edison's, is the employment of an open magnetic circuit.

ELECTRICITY OF CONTACT OF GASES WITH LIQUIDS.—Mr. J. Enright replies (in *Nature*) to Dr. Oliver Lodge's criticism as follows:—"May I be allowed to reply to Dr. Lodge? That the escaping gas was charged was proved (1) by *collecting* it in an insulated vessel; (2) by *generating and collecting* it in insulated apparatus. Electrification resulted in the first case, but not in the second. Details of these experiments I intend to publish later. With all possible respect for Dr. Lodge I cannot accept his explanation of the electrifications I have described. I fail to see any analogy between Armstrong's machine and the experiments with zinc and hydrochloric acid which I have made, except, indeed, that, as I hold, they are all cases of contact electricity. Sir W. Armstrong directs a jet of steam against solid wood grooved and shaped to increase the surface of contact. In my experiment, on the contrary, I find that the effect is distinctly lessened when the hydrogen passes through narrow tubes or openings, and accordingly the strongest deflections are obtained when a large open dish is used. I take an evaporating dish, 8 or 10 inches in diameter, and put a small quantity of a 10 or 16 per cent. solution of HCl into it. The acid is at every point at least 4 or 5 inches distant from the edge of the dish. When a small fragment of zinc is thrown in a gentle effervesence is set up, the hydrogen shooting straight up through the middle of the liquid into the air. I submit that in this experiment whatever electrification results is due to gas and liquid, and not to gas and solid. Moreover, after a lapse of a few minutes, when a sufficient quantity of $ZnCl_2$ gets into solution, the charge on the dish changes its sign. Is Armstrong's machine also in the habit of reversing itself? On this reversal of the electrification I base my case. The dish does not vary, but the liquid does, and its variation is accompanied by a change in the sign of the charge. With regard to the atomic charges I do *not* hold that the charge on the hydrogen has anything to do with them. It is true that at first I set out to inquire as to the equality of these charges, but when I found that the charges on the evolved gas and the generator were of opposite sign, I was constrained to admit that the electrifications were not connected with the atomic charges as I had, during the earlier experiments, supposed. Had I found things the other way—that is to say, that the charge of the gas had been of the same sign as the charge on the generator—I should not have thought it at all improbable that the electrifications were due in some way to atomic charges. In fact, at the outset this is exactly what I thought I might possibly fall upon. However, the unexpected occurred. 'But that a gas should be thus electrified strikes one as improbable.' Can this be so? Surely the distinguished champion of the 'air effect,' who has so stoutly maintained that the contact of copper or zinc with gas gives rise to a difference of potential, cannot consider it very improbable that the contact of a gas and a liquid should produce a similar effect. Perhaps it is well to remember that the hydrogen in these experiments is in the nascent state."

ANOTHER EDISON SWOOP.—A good deal of genuine consternation has been created in electric lighting circles in the United States by the issue to Mr. Edison on 30th August of an extraordinarily sweeping patent for which he had applied as long ago as Feb. 5, 1880. The motto of the American Patent Office is usually "slow and sure," but a delay of seven years between the application and issue of a patent is surely unprecedented. The specification aims at nothing short of covering the whole ground of the utilisation of electrical devices connected in parallel to the source of electricity. The

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claims are eight in number. The first two are as follows:—"(1.) In a system of electrical distribution the combination, with a complete or round metallic circuit, of a number of generators connected in multiple arc with such circuit, and consisting each of an armature revolving in a magnetic field, and a number of translating devices also connected in multiple arc with said circuit, substantially as set forth. (2.) In a system of electrical distribution, the combination, with a complete or round metallic circuit, of a number of generators connected in multiple arc with such circuit, and consisting each of an armature of low resistance revolving in a magnetic field of great strength, and a number of translating devices, also connected in multiple arc with said circuit, substantially, as set forth." The third claim sets forth (in language now quite archaic) the use of shunt wound machines upon such circuits. The fourth claim is broadly for the use of a regulator. In the specification several means of regulation are described, but they are not of an automatic character. The fifth and sixth claims are for the employment of "pressure indicators" for the indication of difference of potential at various points upon the mains. The seventh and eighth claims are as follows:—"(7.) In a system for the generation and distribution of electricity for light or power through cities or towns or districts thereof, a central station whereat are combined a number of generators of electricity connected in multiple arc, and consisting each of an armature revolving in a magnetic field, an indicator of the electric pressure, and a regulator of the current generated, conductors forming complete or round metallic circuits leading from such station to distribute the current throughout the system, and translating devices connected in multiple arc with such conductors, substantially as set forth. (8.) In a system for the generation and distribution of electricity for light or power through cities, or towns, or districts thereof, a central station whereat are combined a number of generators of electricity connected in multiple arc, and consisting each of an armature revolving in a magnetic field, an indicator of the electric pressure, and a regulator of the current generated, conductors forming complete or round metallic circuits leading from such station to distribute the current throughout the system, translating devices connected in multiple arc with such conductors, and meters at the houses for measuring the current supplied to such translating devices, substantially as set forth." According to this the Edison Company actually possesses in America the sole right to every known system of electric lighting except those which depend on simple series connection. Continuous current systems, alternating current systems, direct or indirect supply, secondary batteries, transformers (if in parallel), all seem to come within the comprehensive grasp of these overwhelming claims. We shall await the development of the situation with considerable interest. Meanwhile it may be as well to add that a somewhat similar patent is said to exist in this country. The date is 1881, and it has recently been renewed.

MAGNETISM AND WATCHES.—At the July meeting of the Electric Club of New York, a paper was read by Lieut. F. W. Toppan, U.S.N., entitled "Recent Scientific Discoveries relating to the Effects of Magnetism on Marine Chronometers and Watches." After an interesting account of the evolution of the chronometer (for which the credit rests chiefly with John Harrison, who died in 1766), Lieut. Toppan said: "The chances of injury to chronometers, and to watches especially, by magnetism have been greatly multiplied by the development of the dynamo and its extensive application to electric lighting and other purposes; so it is very common to find magnetised watches in the hands of persons having no connection whatever with electrical appliances. A watch readily becomes sufficiently magnetised to derange its action and render it entirely unreliable. If the regulating part of a chronometer or watch—that is to say, a balance, together with the hair spring—should be badly affected by magnetism, which happens very often, it is clear that the time-piece will suffer more or less, according to the fineness of construction and delicacy of adjustment. Various metals have been suggested to take the place of steel, but it seems to have been left to Mr. Paillard, of Geneva, after fourteen years of experiment, to finally succeed in discovering and producing, in an alloy of palladium, a metal which is uninfluenced by magnetism or corrosion, and still retains those properties necessary to obtain the finest adjustments for changes of temperature. Balances and balance springs made of this alloy are of an expansive property and a specific gravity slightly in excess of steel, but possessed of the very important qualification that it retains its elasticity in heat in a high degree, as verified in observatory trials in various countries, thus reducing one of the worst errors, inherent to a steel balance and spring, aside from its magnetic and oxydable properties, giving us a material which enables us to get a compensation approximating accuracy for a wider range of temperature. Palladium is a metal of the platinum group, and was discovered by Woolston in 1803. Its specific gravity is 11·3, that of gold being 19, steel 7·7 and palladium alloy 8·5. It is more fusible than platinum and melts easily before the oxyhydrogen blow-pipe at 2,840deg. Fahrenheit. In its pure state it is not so ductile as platinum. In producing his balance Mr. Paillard used two different alloys of palladium having a differential expansive ratio in similarity to that of steel. In so doing he at the same time gave us a superior balance, for the two metals composing the laminæ of his balance are congenial, both being made of a palladium alloy and being fusible under different degrees of heat, having the necessary hardness and other qualifications. Numerous searching tests with balances in connection with the palladium alloy springs have given the most flattering results, and we have in chronometers and watches containing these balances and springs superior time-keepers uninfluenced by the hygrometric condition of the atmosphere or any spasmodical electrical condition of the same, and excelling all previous attainments with the steel and brass balance and steel balance spring. This question of magnetism and the necessity for protection of chronometers and watches against magnetic influences has called forth inventions of machines and devices for demagnetising time-pieces that had become affected; also a sort of soft iron shield or armour for enveloping the watch movement, as a defence or preventive against magnetic influences. These are mostly cures after harm has been done. There would be no need of these devices if those parts of the chronometers and watches which control the time-keeping qualities were made of metals absolutely unaffected by magnetism, and yet possessing the other necessary qualifications. In the face of the certain fact that electrical appliances shall become wider and wider in their range, and the aggressive tendency of electricity for lighting and as a motive power, both at sea and on shore, we must be prepared to meet its magnetic influence at every step in our industrial occupations. In the discovery of this alloy of palladium a time-piece has been produced that is strictly non magnetic and non-oxydable, and possessing those requisite and necessary qualities for fine and accurate adjustments to temperature and isochronism, and will take rank among inventions of the highest order in horological science."

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THE RISE AND PROGRESS OF TELEPHONY IN THE UNITED KINGDOM.

(Continued from page 339.)

The action brought by the United Telephone Company against Harrison, Cox-Walker and Co. will long be cited as one of the most remarkable trials of patent law on record. The magnitude of the interests at stake, the perplexity and delicacy of certain of the questions involved, the singularly conflicting nature of the scientific and historical evidence, and the immediate interest felt by the public itself in the issue, all contributed to render the trial a memorable one.

The case came before Mr. Justice Fry on the 24th April, 1887. The plaintiffs sued for an injunction and damages against the defendants on the grounds of an infringement of the Bell patent, by the sale and usage of instruments known as the Cox-Walker and the Hickley receiver, and of an infringement of the Edison patent by the Hunnings transmitter. The defendants did not deny having made and sold the instruments complained of, but the defence set up alleged, (1) that the patent was invalid by reason of the description and exhibition of the Bell telephone at Glasgow in September, 1876, and by reason of the disclosure of the principle in certain publications which reached this country from America prior to the date of the patent; (2) that the invention had been anticipated by the instruments of Phillip Reis. With regard to the Edison patent it was further alleged (3) that the Hunnings transmitter involved a distinct principle of working not described or discovered by Edison, and also (4) that the Edison patent was void by reason of the inclusion in the specification of an invention (that of the phonograph) not properly described in or covered by the title. There were also, of course, numerous minor allegations on the part of the defendants into which we need not enter particularly.

So far as this defence rested upon grounds of pure accident or oversight on the part of the patentees it is scarcely calculated (especially at this distance of time) to enlist much sympathy. The defendants were, of course, legally entitled to benefit by all the mistakes of their opponents; but if the monopoly had been overthrown by this means it would have been a victory of the least satisfactory kind.

In the brief historical *résumé* which is all that these papers aim at affording it is unnecessary to go in detail over the evidence and arguments advanced by either side in a trial which lasted the greater part of a week; and we have merely to summarise the leading points. Taking these in the order already cited, we have, first, the contention of the defendants that the instrument had been publicly exhibited by Sir William Thomson at Glasgow in September, 1876 (the date of the Bell patent being the 9th December, 1876). The circumstances of the alleged publication were these:—At the Philadelphia Centennial Exhibition in August, 1876, Prof. Graham Bell exhibited his telephone while it was yet in an incomplete stage, and, amongst others, to Sir William Thomson. The transmitter consisted of a membrane of skin or parchment, which carried an armature in the form of a flat thin piece of steel spring; the receiver was a hollow cylindrical magnet, with a central core having a flat steel tongue projecting over the core. This armature was not mechanically attached, but was held in place by the magnetic attraction of the core. Its action, as might be supposed, was somewhat feeble and uncertain, but Sir William succeeded in hearing a few words. A little later, on leaving Boston, Prof. Bell placed in his (Sir William's) hands a brown paper parcel, which proved to contain the instruments on which the defendants now relied to upset the patent. There was, however, a not unimportant difference between this receiver and the one at Philadelphia. The armature in this instrument had become a circular plate or disc which was attached to the top of the cylinder by a screw, and was tilted up at a certain angle from the plane of the top of the magnet. On arriving at Glasgow the behaviour of the apparatus caused a good deal of perplexity, both to Sir William and to the assistants in his laboratory. In fact, they could not induce it [no pun intended] to utter a word. The secret, although it eluded even Sir William Thomson at the time, is now easily explained. The fact is that when such a receiver is *pressed tightly* against the ear so that the armature is brought up much closer to the magnet, and also *held down more or less all round*, it then becomes capable of transmitting speech. So long as it was thought necessary to allow the armature to remain loosely attached at one point and tilted away from the magnet its action as a telephone receiver must obviously be imperfect in the extreme.

In September of the same year the meeting of the British Association was held at Glasgow, and Sir William Thomson, in an address to one of the sections, referred to the Philadelphia experiments, and exhibited the instruments he had brought with him, although no attempt was made to use them in public. These were the facts substantially admitted on both sides, the contention of the plaintiffs being that the Glasgow receiver was not a successful invention, that it was not until Bell had made the additional discovery of the immense superiority of a disc clamped all around its edge that a practicable receiver had been produced, and that therefore the description and exhibition of the Glasgow receiver did not constitute publication of the essential principle of the Bell telephone. The defendants were now apparently placed in the anomalous position of having to maintain the success and value of an invention which they had appropriated; but in reality they got over this difficulty by reason of the second branch of the defence, in which it was argued that the Bell telephone had been forestalled by Reis. In order to prove the actual utility of the Glasgow receiver the defence relied chiefly upon the evidence of Prof. Silvanus Thompson who had constructed a working instrument on these lines. This receiver was exhibited in court, and experimented upon by the judge, who was able to hear articulate speech from it. The defendants, moreover, argued that the armature was never intended to be tilted up; that this peculiarity in Sir William Thomson's instrument must have been the result of mere accident. In this they were supported by the evidence of the mechanic who had made some of Bell's instruments at Philadelphia, and who understood that the disc should lie flat upon the magnet. The point was evidently one of considerable importance, though it lay open to the obvious rejoinder that in the understanding of those to whom the alleged "publication" was due, the tilt was taken to be an essential feature of the apparatus and was always so described.

The decision of the learned judge upon this point was against the defendants. "There is no doubt," said Mr. Justice Fry, in delivering judgment, "that some of the most competent and skilled persons who saw it, like Sir William Thomson, came to the conclusion that the disc was intended to be so used, and that the tilt was part of the design and intended structure of the instrument." And the learned judge went on with considerable acumen to point out that this was not surprising, considering that up to this date almost all experiments of this kind had been made with free reeds, which were supposed to be capable of more delicate response than tympans. The value of Prof. Silvanus Thompson's experiment was, in the opinion of the judge, discounted by the fact that the tilt was not so great as in the Glasgow instrument, and that it had only been worked with a carbon transmitter, an appliance unknown in 1876. The judgment (upon this particular issue) was concluded in the following terms: "The burden being on the defendants to show that the anticipation of the Bell receiver by the Glasgow receiver was by an instrument practically as good as the patented one, and of an invention which had passed beyond the stage of mere experiment, I think that they fail in discharging that burden."

There remained a further objection of the same nature—namely, that prior to December, 1876, the invention had been disclosed in this country by the publication of articles both in the English and American press. This was in part true. The *Philadelphia Press* of July 9th, 1876, contained a description of the membrane type of receiver, and in the following August a similar paragraph appeared in the *English Mechanic*. This was the instrument subsequently known to fame as the *English Mechanic* receiver.

It had, however, been clearly shown that the apparatus

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belonged to the experimental stage of the invention and had been abandoned for the superior and more simple type in common use. The plaintiffs had consequently been permitted on 13th Feb., 1876, to disclaim this portion of the specification without prejudice to the remainder of the claims. This objection of the defendants had therefore no *locus standi*.

(To be continued.)

THE WESTINGHOUSE DYNAMO.

The information concerning the Westinghouse alternate current dynamo which has hitherto reached this country has been somewhate incomplete and indefinite, but we are at length enabled to put before our readers a tolerably complete description of this machine.* When it is stated that the Westinghouse dynamos, although only introduced in the autumn of 1885, are now at work in no less than twenty-seven central lighting stations in the States, supplying 72,000 lamps, it must be admitted that considerable interest attaches to the design.

This machine was devised by Mr. W. Stanley, of Pittsburg. Its external appearance is shown in Fig. 1, Fig. 2 is a longi-

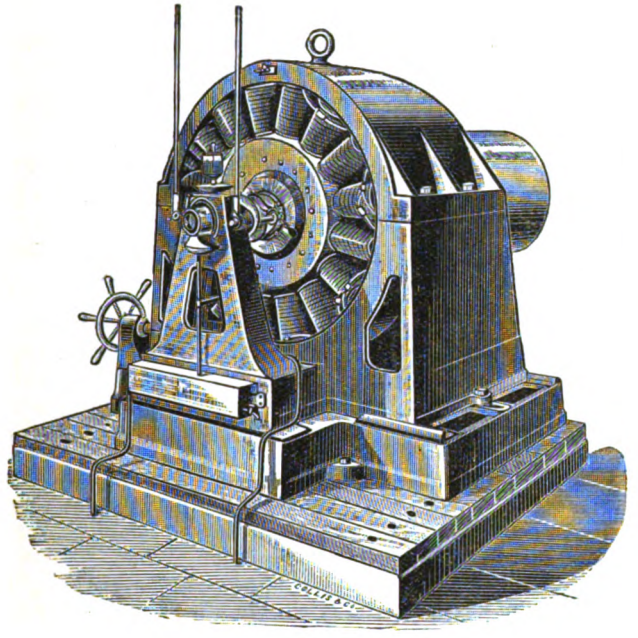

Fig. 1.

tudinal section, Fig. 3 represents the exciter. The foundation of the machine is a heavy cast-iron bed-plate, having projections upon which the standards of the armature shaft are supported. These standards are an integral portion of a single casting, which rests upon the bed-plate, and is held in position by bolts passing through slotted holes, by the aid of which the driving belt may be tightened up by the hand-wheel. The cores of the 16 inwardly projecting field-magnets are fixed to a circular yoke, the lower half of which is formed by the casting just described, and to which the upper half is bolted. The poles, as a matter of course, are of alternate polarity.

The armature is cylindrical in form, and the core is made up of a great number of discs of thin rolled iron placed side by side and insulated from each other by paper. Each plate has six large and a number of smaller holes punched in it for ventilation, and in putting the core together care is taken to keep these holes in line. The discs are clamped together by thicker end plates, which are seen in Fig. 1. The armature winding is somewhat peculiar. First of all, along the periphery of the cylinder are fixed a number of insulating strips which project like Pacinotti teeth, and are secured at either end, where they overlap. The wire is then wound around these strips across the face of the cylinder parallel to the axis, while each turn passes at either end under the insulating strip, so that at the bend it lies in a plane at right angles to the line of the shaft, or, as it may more simply be stated, the ends of the core are bent over parallel with the *end* plates of the cylinder. Each coil, it will be understood, is separately wound, and lies on the outside of the cylinder, as in the obsolete

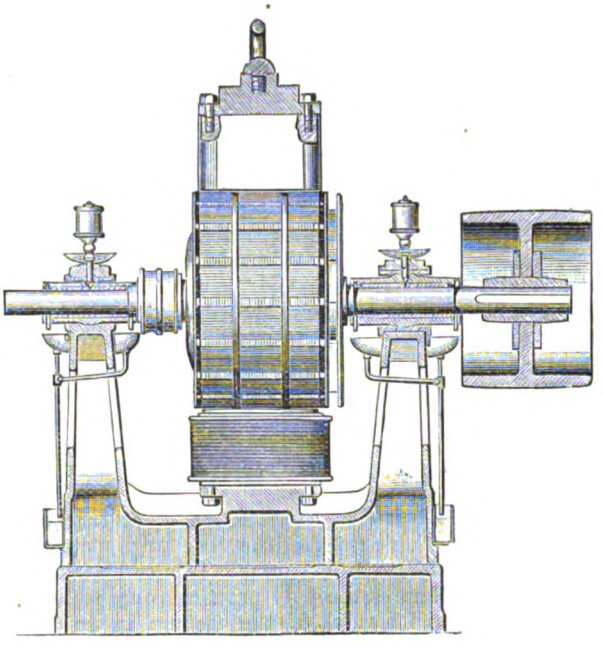

Fig. 2.

Elphinstone-Vincent machine. We have been careful in explaining this point because it does not appear in the illustrations. Washers are fixed to the ends of the armature to prevent the external plates from touching the wire. The outer

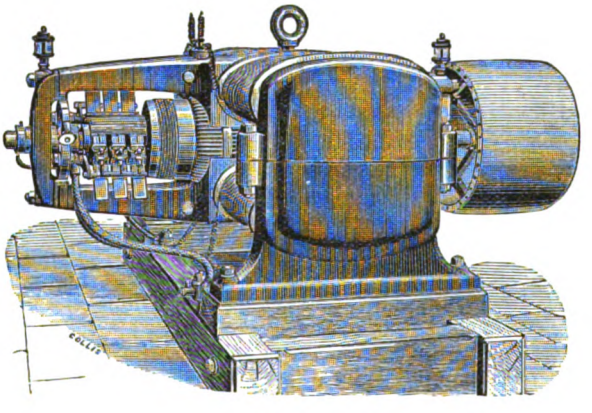

Fig. 3.

surface of the wire is then covered with sheets of mica, and the whole is finally wrapped with two parallel bands of binding wire, wound circumferentially. This is plainly seen in Fig. 2. The connections of the armature are practically the same as in the Siemens machine, and may, of course, easily be varied for different E.M.F.'s. The total weight of a machine of the size illustrated, which is rated at 650 16 candle-power lamps, is 5,000lb. It is run at the comparatively high speed of 1,650 revolutions per minute, and though we have not got the dimensions of the armature before us, we believe that we are correct in saying that the peripheral velocity amounts to somewhere about 8,000ft. per minute, a figure which we need hardly say is considerably higher than that which obtains in English

* Our illustrations are taken from an article in the *Electrical World* of September 3rd. Some information has also been obtained from a paper by Mr. F. L. Pope in the New York *Electrician* for the present month.

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practice. The E.M.F. ordinarily employed upon the transformer circuit is from 1,000 to 1,100 volts.

The exciter is a Stanley machine, shunt-wound, of which we have at present no further particulars. It is stated that only 2 per cent. of the total electrical energy produced is required for excitation. This is, of course, the result of the high speed employed.

CORRESPONDENCE.

INCANDESCENT LAMP MANUFACTURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Now that Mr. Swinburne appears to have concluded his very interesting series of papers on the manufacture of incandescent lamps, I suppose the subject may be considered as being fairly opened for discussion in your columns.

As there are several matters upon which opinions may differ in regard to detail in this manufacture, and as I have had a good deal of experience in connection with it, I propose to write (if the same will be acceptable to your readers) a few letters on the subject. I do not intend in so doing to offer, as a rule, any criticism upon what Mr. Swinburne has said, but merely to put on record a few observations of my own for what they are worth. I may resay something Mr. Swinburne has said before me, but if I do it will be only because his and my experience on such points will have been the same.

As I am not writing a series of articles I shall feel no necessity to keep to any particular order in dealing with the subject on hand. I will therefore plunge at once into the midst of affairs:—

Everyone who has had any experience of storing lamps in any quantity must have noticed the very large percentage of them which deteriorate in vacuum. The coil test to which Mr. Swinburne refers is the only practical one which can be employed to assess the value of the vacuum in an exhausted lamp. If we take a "good vacuum" lamp and place one of the terminals of a powerful induction coil in connection with its platinum wires, and the other terminal of the coil a short distance from the bulb, a series of sparks can be made to strike the glass in the same or nearly the same place, and if this action be continued for a certain length of time, dependent on the thickness of the glass and the strength of the discharges, the glass will be punctured and the air will stream in. If the coil discharges are continued whilst the air is entering a most beautiful series of phenomena will present themselves, and all the phases of vacuum discharge, from the total absence of discharge of any kind caused by a vacuum above the point at which any discharge takes place down to simple sparking in a globe full of air, can be studied as they merge one into another during the operation. If care be taken in the experiment, and the punctured hole be made small, *i.e.*, by keeping the discharges at first of minimum force, and by turning the lamp so as to expose a fresh surface to the sparks when the first indication of puncture is seen, the entrance of the air may be prolonged during several minutes, so that ample time will be given for observing the various changes that take place in the discharge.

In almost all the cases I have dealt with in this manner, the bulb of the lamp has been more or less filled after a few minutes' strong discharge with a bluish-grey light before puncturation. The moment of puncturation may be detected by the sudden appearance of a reddish crimson colour, which is, I believe, due to the nitrogen of the air. If we arrest the experiment when the bluish light is shown in the bulb we shall find that in most cases the deterioration of vacuum indicated thereby is permanent, though sometimes the gas causing this colour to appear under the electrification described is partially reabsorbed.

The experience of testing many thousands of lamps for vacuum by the coil teaches us that lamps which have been stored and whose vacua have "gone down" exhibit almost invariably the same bluish-grey light under electrification as is seen when a really perfect vacuum (in an incandescent lamp) is destroyed under heavy discharges of the coil in the manner referred to above.

The old explanation that the lowering of vacuum of well-exhausted lamps arose from minute leaks around the platinum wires, &c., would appear untenable in the light of this experiment, as if *air* leaks into the lamps the characteristic red colour given by nitrogen would be developed on electrification; whereas there is not, according to my experience, one per cent. of lamps suffering from declension of vacuum in which there is any trace of the coloration due to nitrogen.

Under these circumstances one is driven to look elsewhere for the source of the gas (whatever it may be) which by being occluded into the lamp injures its vacuum.

A course of experiments made some years ago led me to the conclusion that this gas comes from the platinum wires used to support the carbon. The following experiment was tried in illustration of the subject.

About 6ft. of platinum wire were rolled up into a helix and the two ends were passed through the ends of an oval-shaped bulb and sealed in, in the ordinary manner. The bulb was then sealed to a pump and exhausted. As the exhausting proceeded the vacuum was tested from time to time by the coil. An unusually large amount of the bluish-grey colour continuously developed itself, making the exhaustion very tedious. When at last the vacuum seemed perfect, a small current was passed for a moment through the platinum wire, when the gas giving the bluish-grey colour with the coil was given off in great abundance. This was again pumped out, and again a second passage of a current through the wire produced a similar result. After a second pumping the platinum wire was heated by a current to dull redness for a few seconds, when the development of the characteristic gas was so great as to quite obscure the interior of the bulb when the electrifications with the coil took place; after again pumping, the wire was made red hot, full red this time, so as to be in danger of sagging against the bulb and breaking it. Owing to this tendency the current had to be put in for only a second or two at a time. The process of pumping and heating was carried on alternately for a long time, until at last it appeared as if all the gas had been given off, and heating the platinum to redness no longer seemed to develop any further deterioration of vacuum. At this point the bulb was sealed off, and the vacuum appeared to be perfect. The next day, however, the vacuum in that bulb was by no means perfect, and within a week it was bad, there being an abundant development of bluish-grey light on the application of the coil test.

In a subsequent experiment I endeavoured to entrap some of the gas given off as above described by the platinum, by sealing a small tube into a bulb, in which the platinum wire experiment above detailed was repeated. When, after careful heating, the gas appeared to be at its maximum, the small tube was sealed off; into this tube wires had been previously sealed to serve as terminals. A powerful discharge was now sent through the small tube, and the spectrum of the luminous discharge was examined. All I can say about this examination is that the result appeared to me very curious; the lines which appeared in the spectrum did not appear to coincide with the lines given for any substance in any text book I could find, and I could only suppose that the gas which is occluded from platinum is so far changed—as regards some of its properties, at least—that it gave—1st, a characteristic bluish-grey light under electrification; and, 2nd, lines in the spectrum not like those given by the same gas before its absorption by the platinum. I had not time to pursue the subject beyond a very few rough experiments, and these conclusions may be wrong.

Whether gas which is occluded from platinum is in any way altered or not by its temporary sojourn in the platinum, it will be abundantly evident to any one who will try the experiments indicated above that the amount of gas given off is comparatively enormous. In several instances I have found that repeated heatings to redness in vacuum, although apparently removing all the gas for the moment, have not ensured the non-appearance of the same sort of gas at a future time. This has so often been observed that one is almost tempted to think that platinum may be porous so as to let gas right through it. The thing looks at the first absurd, but if it be true that water "sweats" through cast iron

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under pressure—as in a hydraulic ram—I cannot see any inherent impossibility in gas "leaking" through another metal at a lower pressure. The chief difficulty that appears to be involved in such an idea arises from the fact that the effect does not always appear. I believe platinum is commonly "made" by heating a powdery or granular mass to a welding heat, and then treating the same under hammers or rolls. If this be the case, it is easy to imagine, in view of the high temperature needed to melt the metal, that the welding may be in many instances imperfect, and wires drawn from bars so formed may very well have the defects of the original welding reproduced in them, and thus mechanical passages may be afforded for the air or gas. The whole subject is one which I think would well repay careful experiment.—Yours, &c.,

NELSON K. CHERRILL.

FORMULÆ FOR SELF-REGULATING DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question asked by "M," whether the mathematical formulæ given in my book for the conditions necessary for the self-regulation of dynamos are found to be in accord with the practice of manufacturers, is readily answered. The formulæ themselves are in general not; the practical conclusions to which they lead are. For example, the formula No. XXVII. for compounding a dynamo for constant potential is not verified in practice. More series turns are required than that formula indicates, and the reason is simply this: The assumption is frankly made at the outset that the iron in the field-magnet cores is never saturated, and that its magnetism is therefore always proportional to the number of ampere turns exciting it, whereas in actual constant potential machines the series coil is required to come into use most powerfully when the iron cores are well on toward saturation; hence, more series turns are wanted than the theory indicates. But, on the other hand, the practical rule which follows for ascertaining by experiment how many series turns are actually wanted to give self-regulation is constantly used by manufacturers of dynamos. Again, the formulæ for compounding machines, to make them self-regulating for constant currents, are not used, for the additional reason that they would involve an enormous cost for the immense number of turns of wire in the shunt winding. In the expressions for self-regulating motors the formulæ are, however, again good, because in the constant speed motor, running on constant potential mains, the maximum power exerted by the series coils is called forth, not when the field-magnets are most powerfully excited and well saturated, but when they are least excited and furthest from saturation. There will be something said on these points in my forthcoming new edition,—Yours, &c.,

SILVANUS P. THOMPSON.

London, Sept. 20th, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note in last week's *Electrician* an inquiry as to the practical value of the equations in Silvanus Thompson's "Dynamo Electrical Machinery." The formulæ as mere abstractions are undoubtedly correct, and were it not that the saturation coefficients and the self-induction of the armature are extremely difficult to determine with the ordinary instruments of the workshop, they would be of undoubted use. But, unfortunately, the characteristic of a dynamo or motor does not depend merely upon either the armature or field saturation curves. The characteristic is really the resultant of, firstly, the field saturation; secondly, the armature saturation; thirdly, the depth of the air space; and, fourthly, the external leakage of the lines of force, which depends on the shape and extent of the pole-pieces. Any formula to be of practical value must take into consideration each of these, and we must also assume that they can all be accurately and easily determined by an ordinary electrician with ordinary reading instruments. As an example we may say that using the formula for compounding a dynamo for constant potential we found the series turn to be *one*, but the actual number required was fifteen.—Yours, &c.,

DYNAMO MAKERS.

[CORRESPONDENCE *continued on page 417.*]

OBITUARY NOTICES.

MR. FRANK LAMBERT.

We very much regret to record the death of Mr. Frank Lambert, which took place on Wednesday, the 14th inst. Mr. Lambert was born at Brighton, Sussex, in January, 1836, and was educated at the Grammar School. He served his apprenticeship to Mr. Funnell, watchmaker, of Brighton. The early training in delicate workmanship thus obtained was of the utmost service in his future career. In 1856 he made his first acquaintance with electricity under Mr. E. Orange W. Whitehouse, by whom he was engaged on experiments on the problem of working Atlantic cables. In 1861 he was employed under Messrs. Gisborne and Forde upon the cable made to Government order for a line between Rangoon and Singapore, but which was eventually laid between Malta and Alexandria. Soon after this he joined the staff of Messrs. Sir Charles Bright and Latimer Clark, and was engaged under Mr. Laws in testing the core of the first Persian Gulf cable, when some valuable experiments were made at the Gutta Percha Company's works in Wharf-road on the resistance of gutta percha at various temperatures, from which the tables, now in constant use, were compiled. He served as second electrician on the laying of the Persian Gulf cable in 1863–4.

About the year 1866 Mr. Lambert was appointed by the Indian Government to make a tour in India as instructor to the telegraph staff in electrical matters. This tour occupied him until the end of 1869, and on his way home in 1870 he assisted Mr. Forde during the laying of the cable from Bombay to Aden to Suez. Since that date he has remained in the service of the well known firm of Clark, Forde and Taylor as principal electrician, and has been engaged in the laying of cables in all parts of the world. He was the inventor of several improvements in the keys and other details used in the high-class testing employed for submarine cable engineering. He was also one of the original inventors of "cutting and holding grapnels." He was a member of the Society of Telegraph-Engineers, and a most careful and skilled electrician, respected and liked by all with whom he was ever associated.

CAPTAIN A. H. J. RICHARDSON.

It is with great regret that we have to record the death of Capt. A. H. J. Richardson, late of the Eastern and South African Company's ss. "Great Northern." The late Capt. Richardson caught a fever while on duty on the East Coast of Africa, and was invalided home. He died on Sunday morning, the 18th inst., and his loss is deeply regretted by his numerous friends. Capt. Richardson was born in Saxony. He was forty-six years of age at the time of his death. He joined the Eastern Telegraph Company's service in October, 1870, and worked through the several grades of service to that of commander of the ship. For a brief time in 1874 he was with Capt. Briscoe in the "Hawk," and it was in 1880 that he was given the command of the ss. "Great Northern," stationed at Zanzibar.

It will be seen from these brief notes that he was a man of great experience in his profession, and one who has done good service in cable work. On several occasions it has been our good fortune to meet with Captain Richardson; we have found him always ready to give us the benefit of his experience. He was a general favourite with those with whom he was brought into contact. It may be remembered that he was one of the survivors in the disaster which overtook the "Volta." The remains of the late captain were interred yesterday (Thursday), when a great many of the Eastern Company's officials followed the body to the grave.

MR. O. E. WOODHOUSE.

At the moment of going to press we regret to have to add one more name to our obituary notices this week in the person of Mr. O. E. Woodhouse, senior partner in the firm of Woodhouse and Rawson. Mr. Woodhouse died at Brighton on Wednesday, after an illness of nearly two years' duration.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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ELECTRICAL COMMUNICATION WITH LIGHTSHIPS.

Some considerable surprise, not unnaturally, has been occasioned by the Report of the Committee appointed by the Board of Trade to inquire into the desirability of establishing electrical communication from the shore to light-vessels and outlying lighthouses. One passage in that report—which is a very brief one—has especially provoked a good deal of adverse comment. "Without denying," says the Committee, "the very general proposition that all communication with lightships and lighthouses which tend to the saving of life at sea would be desirable, your Committee feel that their decision must evidently depend upon other considerations, very mainly upon that of cost; and bearing that important element in mind we are of opinion that the immediate extension of the system is not desirable." These words, taken by themselves, appear to put the question of expense foremost, and the saving of life virtually nowhere. But in fairness to the Committee it must be confessed that this is not a quite accurate representation of its attitude. After pointing out that the experiment on the "Sunk" Lightship has not been exhaustively tried, the Committee recommend that a final decision should be postponed for eighteen months, and that meanwhile the experimental cable connecting Walton-on-the-Naze with the "Sunk" should be continued. With regard to establishing electrical communication with outlying light houses and islands, Her Majesty's Government is advised to carry through Parliament the Bill for the acquisition by Lloyd's of sites for signal stations.

Although the Report is unusually brief and its conclusion apparently indecisive, the evidence and appendices published with it are voluminous and extremely valuable. A candid perusal of both will afford ample justification for the conclusion arrived at by the Committee, at all events with regard to the particular proposition submitted for its consideration. The special object of the inquiry was that of "facilitating the saving of life at sea," and much of the evidence was directed to this point. But not to this point chiefly, a much larger question very speedily usurping its place, the question, namely, of employing the proposed electrical communication for purposes of signalling ships, transmitting marine telegrams, and generally for commercial objects. Directly the investigation took this turn the subject assumed a quite new aspect, excluding the other, and, as most people will think, more important one, out of sight altogether. For one thing the POSTMASTER GENERAL had to step in to assert his right to give or withhold license for the use of cables landed on British soil intended for the transmission of messages. And although it is perfectly true that the Post Office grants such license with the utmost readiness and on terms which nobody can object to, the assertion of its rights in this relation naturally gave a quite new direction to all the evidence following. It is one thing to lay down cables with the object of signalling for assistance to vessels in distress; it is quite another to employ these cables for signalling messages from ships that wish it to be known they are safe and sound. This latter object is an extremely important one from a commercial point of view; so important, indeed, that not only Lloyd's and certain Steam Line Companies, but even Shipping Newspapers have found it worth their while to establish, with the consent of the POSTMASTER-GENERAL, signalling stations at remote or detached points of the English and Irish coasts, in order to insure early information of the whereabouts of outward and homeward bound ships.

The proposal to use such lightships as the "Sunk" for similar purposes may or may not have been an afterthought, or it may have been in the minds of the promoters all along. In either case the object is quite a legitimate one, and no blame can be attached to them for endeavouring to combine the two, especially as the pecuniary profit likely to be derived from serving the one object would in many instances afford considerable help to achieve the other. In plain words, the costliness of the cables and the expense of working them would be lightened if they could be made to earn something at signalling stations. This, we say, was a perfectly sound and business like suggestion; but it was not exactly what the public were looking forward to. They wanted the lightships connected by telegraph, with the idea of being enabled more quickly to render help to shipwrecked mariners, and are naturally disappointed that the scheme is set aside, or at all events postponed, on the ground, apparently, of expense alone. But this in reality is not the sole ground; and if the promoters are disappointed with the result of the present inquiry they have chiefly themselves to blame. Or perhaps it would be fairer to say that they could not help themselves. The case for saving life broke down at an early stage, and the representatives of the company that laid down the cable to the "Sunk" had to admit that the twelve months' experiment had in that respect not been a great success. No doubt there are situations—off the Norfolk coast, for example—where a series of lightships, connected with each other and with the coast, would be of frequent service in indicating the fact of shipwreck, and its exact position. The evidence of coastguards and lifeboat crews

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was positive on this point, and we are inclined to agree with it. But, on the other hand, the experts of Trinity House are equally positive that their mission is and ought to be not to save life from wreckage, but to prevent wrecks; and that additional lightships provided with sirens or explosive signals of the newest type are the fittest objects on which to spend public money.

The promoters of the cables do not for a moment attempt to gainsay this proposition; on the contrary, they are as earnest as anybody in their protestations of anxiety to prevent disaster at sea. But they were probably not prepared for the attack made upon their scheme in the form of an objection to its commercial signalling functions. The company's witnesses had urged that in several instances which were cited—notably at Brow Head and at Dover—vessels had been driven into dangerous waters and wrecked through making for signalling points on land. But to this it was retorted that not only would lightships be in danger, of being fouled when approached with a similar object, but that as the situation is always one of danger ships should rather give it a wide berth than be tempted to get near enough to make their signals known. Captain HALPIN admitted that "a great deal of their usefulness as telegraph ships would be lost" unless the lightships were used as signal stations; and indeed to Q. 1,220 ("Your idea would be to make telegraph stations of them?") his answer was "Yes; more in that way than in any other." It is not surprising that the matter was promptly put "in the other way," namely, as to the relative "advantages you would get by telegraphic communication to lightships for reporting" compared with "the risks you would expose the lightship station to." And to this the witness was "not prepared to say how that would be." In a report addressed by Mr. GRAY and Captain NARES to the Permanent Secretary of the Board of Trade, as long ago as June, 1886, this point was treated as one of principle, and it was submitted for serious consideration whether to "encourage ships to approach a lightship in order to use it as a Post Office Telegraph Station, might [not] be to encourage them to approach a danger, and thus prevent the object with which the light-vessel is established."

This is the official view, and it is backed by a long list of light-vessels which have been fouled and damaged more or less during the past six years, when the object has been not to approach but to keep clear of these beacons. The damage done, however, has rarely been serious, and only on two occasions has the light-vessel been sunk. Possibly the list would not have been greatly enlarged had the vessels been used as telegraph stations; and of course none but those situated in positions convenient and safe for passing ships would be specially selected as signalling stations, unless, indeed, experience proved that the greatest safety was insured by multiplying facilities for the interchange of signals. It may also be suspected that the official objection is more on the score of saddling this or that Department with the expense than of the expense itself. The line taken by the Trinity House is that "We do not want the cables for Trade purposes, and, therefore, we do not want to pay for them;" and the Board of Trade follows suit. Fortunately there are other Departments, not Governmental, that do want the cables for Trade purposes, and we venture to think will soon possess them. We venture also to predict that so soon as the telegraphic communication is fairly established by private enterprise, if not by public Departments, with outlying lighthouses, or lightships, the Trinity House and Board of Trade will discover that there is no serious danger attending it, and that it will come in very handy for saving life as an adjunct to the Lifeboat service.

On one point, happily, there is no material difference of opinion. The cable laid by the TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY to the "Sunk" Lightship in March last year has been a complete success. At all points where difficulty was expected it has been easily surmounted; and where interruptions of temporary duration have occurred they have been due to the unexpected—mainly, indeed, to the peculiarly capricious behaviour of this particular ship, which besides being smaller and less buoyant than most vessels of its class, is fitted with an old type of windlass, and has to be frequently "veered" to prevent her light being wholly obscured by every high sea. She turns round twenty times in one direction to once in the other direction, and the consequence is that the telegraph cable gets twisted round the ship's moorings, the unwinding having to be done by manual labour instead of by the ordinary swing of the vessel. The marvel is that, notwithstanding the swivel arrangement with which it is provided, the cable has lasted so long. But, in reality, it remains perfectly sound, and speaking by telephone at all seasons, in storm as in calm, is as easy and trustworthy as on a corresponding length of land line. This cable, nine miles in length, has, in fact, been put to a test more severe than any to which cables of the same pattern would be subjected on the other lightships, none of which are so ill-suited for taking a cable on board as the "Sunk." If no other useful purpose than to establish this fact had been served by the Board of Trade inquiry its Blue Book would be very welcome. But it has done more than this; it has resulted in recommending a further extension of the experiment for eighteen months, and the granting to Lloyd's the sites for signalling stations which Trade purposes, if not Life-saving objects, urgently demand.

THE JABLOCHKOFF PATENT ON DISTRIBUTION BY TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: An unintentional misstatement is made in your review of Mr. Kennedy's papers on "Electrical Distribution." It occurs in the following passage:—

"Chapter III. contains a detailed enumeration of the various patents which have been taken out dealing with systems of distribution in which transformers are employed. The earliest of these is that of M. Jablochkoff, in 1877, who proposed to make use of induction coils with vibrating interruptors for feeding his candles with a higher E.M.F. than that in the mains. We believe that the present owners of this patent contend that the claims cover the whole ground of the use of transformers for distribution, and entitle them to the exclusive use of the method. In November, 1878, a provisional specification (No. 4611) was filed by Messrs. E. Edwards and A. Normandy, in which the use of alternating currents with induction coils was for the first time (?) described. This patent was not proceeded with, but the appearance of the provisional specification having constituted publication, it is difficult to see how any 'master-patent' of still later date can be established. The Gaulard-Gibbs specification is dated 1882, and follows closely on the lines of the 1878 specification above referred to."

Our rights are based on broader grounds than these, and to prevent any misconception that might arise, permit us to draw attention to the following extract from Jablochkoff's patent of 1877, of which we enclose complete copy:—

"Fig. 3 shows the arrangement *in which alternating currents are employed*, such as those produced by most magneto electric machines. This arrangement only differs from the preceding one by the omission of the interruptor and condenser. The coils here shown are similar in construction to those for which the before-mentioned previous Letters Patent

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have been granted to me. In this case the total system of distribution may consist of a central circuit represented by the series of internal wires of the coils, from which branch out as many distinct conductors as there are bobbins in the circuit. Each lamp is therefore perfectly independent, and may be lit or extinguished separately. The distribution of electricity in a building to be illuminated is in this case similar to the distribution of gas. *As a great number of induction coils can be placed in the circuit, and as a number of lamps may be placed in the circuit of each coil, it will be seen that the electric light is thus capable of very great sub-division.*

"Second ('claim'). The use in apparatus for the production of electric light of induction coils interposed in a primary electric current for generating separate and independent currents to be used for producing electric light in one or more lamps interposed in such secondary circuits, substantially as herein described."

Jablochkoff's claim was complete *before* Edwards and Normandy filed their specification, and constitutes the "master-patent" you imply.

We would not encroach on your space with the correction, but that early developments will require a recognition of our rights in the system generally described as that of "Distribution by means of Secondary Generators."—Yours, &c.,

MANVILLE AND MADGEN,
Managing Directors of the United Electrical Engineering Company (Limited).

Lambeth, September 21st, 1887.

RULES FOR INSTALLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The rumour of a misunderstanding between the Society of Telegraph-Engineers and the fire offices with reference to the Phœnix Fire rules has astonished me a good deal. I had hoped there was no foundation for it; but the letter of your correspondents "Electrical Engineers" leaves little doubt of its truth. I very much regret that this should be the case, the more so at this critical period in the history of electric lighting. The mere whisper of a doubt as to the safety of the electric light, or the sufficiency of the existing fire regulations, may stop orders for lighting theatres and places of public amusement.

I, myself, see no reason for a change. I have used the Phœnix Fire Office rules from their commencement, and have never had any difficulty in complying with them or in getting the work passed by the offices. I mention them in my specifications, and shall continue to do so; indeed, I consider it would be a matter of gain to the electrical profession if the Phœnix rules were generally enforced. Their adoption would determine a standard for specifications, and would prevent the absurd estimates we see daily. But quite apart from the professional aspect, the *risks* are insured by the fire offices, and not by the Society of Telegraph-Engineers, and surely the offices have a right to settle the basis upon which they will accept such risks. Does the society imagine a new set of rules would be generally adopted? *Perhaps a few offices might use them.* I know for a certainty that nearly all the fire offices in this country are with the Phœnix in this matter of rules, and use them. Among so many offices it is quite possible one or two may not care for them, not on account of the "rules" themselves, but from trade rivalry. Are we electrical engineers to play into the hands of the few, and alienate the sympathy of the far greater number who are not only well disposed to the industry but have been our good friends in the past? Such a course of action can only end by throwing the industry into confusion and retarding its progress. I hope, Sir, most sincerely, that the matter will be settled in an amicable way, and that the very efficient set of fire regulations known as the Phœnix rules may be not only allowed to stand but be generally enforced.—Yours, &c,

ANOTHER ELECTRICAL ENGINEER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Whether there is any truth in the rumour that we are to have a set of rules from the Telegraph-Engineers I do not know, but certain it is that the Telegraph-Engineers attempted to suppress the Phœnix Fire Office rules, and issue these same rules, under one of their own covers, as coming direct from the Telegraph-Engineers. The Phœnix Fire Office were willing to meet the society in every way, but insisted that due acknowledgment should be given to the fact that they were the "Phœnix" rules. Negotiations were carried on for some time with a view to compromise; but these ultimately fell through, and the result may probably be as your correspondents "Electrical Engineers" suggest, a set of rules from the Telegraph-Engineers. A more unwise proceeding could not be. I feel positive all good firms will stand by Mr. Heaphy. I for one consider his rules excellent. Many is the hour I have spent with him, and never have I had the slightest trouble in complying with them. We know these rules, and are familiar with them, and I venture to say we shall not easily lay them aside.—Yours, &c., J. M. V. MONEY-KENT.

Connaught Mansions, S.W.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read the letter of "Electrical Engineers" in your last edition in reference to the above subject. I am quite astonished to hear that there is any idea of the publication and enforcement of new "rules." Anything more disastrous to the trade it is hardly possible to conceive. At a moment when the talk of the safety of electric lighting as against gas lighting in public places of amusement is paramount in the minds of the public, and when the proprietors of these places of amusement are seriously thinking of replacing gas by electricity, can anything be more likely to shake their faith in electric lighting than to give them any idea that differences of opinion as to security are possible? Even *if* it were true it would be in the highest degree impolitic; but what can we say when there is really no cause whatever to reopen the question?

The Phœnix Fire Office rules composed by Mr. Heaphy are the result of long and practical experience, an experience which it is only possible to attain by every case of accident being brought before one's notice; and Mr. Heaphy stands in the unique position of probably having seen every case in England of fire from electricity. How, then, can a few gentlemen who have not the opportunity of acquiring the knowledge which Mr. Heaphy's position has brought him improve upon Mr. Heaphy's rules? I myself have erected a good many of the most important installations in London and the country, and one or two of them are, I think, amongst the heaviest fire risks the fire offices have. In every case I have followed the Phœnix Office rules, and in no case have I ever had the slightest trouble with the fire offices, in no case have I had trouble in getting the installations passed, and in no case has any electrical fire occurred. Nor can I conceive it possible that a fire could occur if the rules are carried out in their integrity; and I shall continue to adhere to them. I know to a certainty that almost all the large offices have decided to follow the Phœnix Office rules, and it would be interesting to know who those offices are who object to follow them, and what good they have done for electric lighting.—Yours, &c., SAFETY.

THE D'HUMY BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read in your paper an account on my "Water Primary Battery," signed "Iconoclast." It is a pity the space of a valuable paper like yours should accept to print such a false statement, simply to ruin our invention. "Iconoclast" is a perfect ignoramus. When he says that Mr. D'Humy is so ingrossed with his invention that no one has a chance whatever of seeing him, no matter what time of the day or night, or even if one waits all day, it is impossible

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to get the desired audience. It is so untrue, that I receive about six or seven hundred people a week, and as tired as I am I have never let anybody wait for me three minutes.

It is not with *jeux de mots*, and that *en passant*, "Iconoclast" proves that he is not only a defamator, but a man animated with jealousy.

If you will do me the honour to give me an appointment at my office at the address below, I shall make it my duty to show you a primary battery adapted for central stations and not for private house use.

Whatever may be your opinion on my invention, I forbid Mr. "Iconoclast" to say that I am never at my office. If "Iconoclast" is kind enough to give his real name and address I shall send him an invitation, and he will meet me at my office with people ready to prove how wrong he has been to injure a man in writing such an untruth in your paper.—Yours, &c.,

F. D'HUMY.

The Water Primary Battery Co., Limited,
26, Grays Inn-road, E.C., 17th Sept., 1887.

[We have omitted one or two sentences of this letter which seemed to us merely reiteration of the same statements. The value of the Water Battery is neither increased nor decreased by M. F. D'Humy being found in or out of the office; and in the interests of the investing public we invite a reply to the technical criticism which, after all, may be discovered in "Iconoclast's" letter.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A portion of my last letter was made to appear very ridiculous through a printer's error. It was $Z = 1$; it should, of course, have been $\eta = 1$, the economic coefficient. But possibly Mr. D'Humy has by this time pointed the error out to you himself in a letter of thanks he is sure to publicly accord me in your journal for the points of this battery to which I drew special attention.

Now for the Press notices.

The most important are those of the *Investors' Guardian*, *Iron*, and *The Morning Post*—most important, not only to Mr. D'Humy, whose "inventions" they rightly determine shall not remain in oblivion, but chiefly on account of the weight we must attach to the utterances of such judges of things electric as these journals undoubtedly are.

The *Investors' Guardian* pictures a smiling incredulous gas shareholder paying a visit to Gray's Inn-road. He sees the wonders of that domain; astonishment sways his quivering limbs. He comes out smiling? Oh, dear no; but with a face as long as a pump handle. He is living in a fool's paradise. (To comp'ete the picture we must imagine that his smile again returns. He rushes off to the city, sells out his gas shares, rushes back to Gray's Inn-road. Has he not the *Investors' Guardian* as his guide?)

The same paper assures us that the battery has special and marked features, to which its efficiency (you will recollect, Sir, that $\eta = 1$) is due, and these features rolled into one result in an electromotive couple of great efficiency. Children may light up whole suites of rooms, and may handle the water battery *without danger to its efficiency.* (To think how often I have stumbled over ζ, η, and θ, and in these days children may even play with η without risk.) "It only remains for us (says this authority) "to add that we have made a most thorough and searching investigation of the water battery, and the more we ponder our notes and weigh all the probabilities the more convinced we are that the public have at last secured the light of the future." This seems like half the capital already; even the office boy could not withstand such a straight tip.

Iron assures us that a water battery of twenty cells gives thirty-five volts (? ? ?—the queries are my own, printers' errors run in my head to-day) and forty amperes, and produces 1,000 candle-power incandescent light when divided into 10 candle-power lamps. The lamps, therefore, require only 1·4 watt per candle. [Whose can they be?—ED. *E.*]

The next paragraph must be quoted in full. "By using a different potential of lamp on the same wire, he lights up successively glow lamps varying from 3 candle-power to 1,000 candle-power, and from 1 candle-power from 3 volts to 1,000 candle-power divided from 3 volts to 100 volts. One of the most striking results achieved by Mr. D'Humy is when, by simply turning a switch, he sends the current into a lamp of 100 volts (giving 1,000 candle-power incandescent light), and at the same time and by the same wire another current into a 50 candle-power glow lamp." I quite admit that the effect of putting different volt lamps on the same pair of mains would be very striking. *Iron* also tells us that Mr. D'Humy has a meter that controls *the light consumed per minute*, "a most ingenious arrangement" (without doubt), and *hence* "house-to-house lighting is made perfectly practicable," and winds up by saying that "London must hide its dull, unenlightened head as far as electric lighting is concerned," for only allowing Mr. D'Humy to put down 3,000 lights, whereas abroad he puts them down by the 100,000.

The *Morning Post* endorses in the heartiest fashion every word *Iron* says, especially with reference to the meter, believing that one that controls *the light consumed per minute* renders house-to-house lighting practicable. Quotha: "It is by means of this ingenious arrangement that house-to-house lighting becomes practicable." The "sub-division" of the light is another "feature." "There are thus four important factors—small initial cost, comparative cheapness of maintenance, great durability, and extreme simplicity of manipulation, which latter includes the ingenious division, switch, and meter arrangements."

Barker's Trade and Finance chiefly copies the prospectus. *Money* assures us that nothing but the addition of water to the outer cells is required to maintain the action of the battery.

The *Daily Recorder* is jubilant, and gives us the most remarkable particulars. In describing the exciting elements it ends by saying that "the result is an *electro-motor of great efficiency at an almost nominal cost*," and we are assured that a specimen can be seen working daily at the "Water *Primary* Battery Company's offices."

"The batteries and accumulators giving a current for twenty-five lamps of 10 candle-power can be supplied to the public for an outlay." No doubt you forgot how much! Why didn't you, Mr. *Recorder*, put it down in your notes and "weigh them" like the *Investors' Guardian* did? You are, nevertheless, of opinion that as far as you have seen it is one of the most marked developments of electric power, both for lighting and motor power, which has been produced for some years past, and you say it has been taken up largely by the French Government.

Such, Sir, are the remarks and opinions of the daily journals. Can a boom in the shares of this "Water Primary Battery" be anything but a certainty?—Yours, &c.,

ICONOCLAST.

[We insert these letters of "Iconoclast" more to show the stupidity of penny-a-liners whom he quotes in matters electrical than as directed for or against any primary battery.—ED. *E.*]

GAS IN LIBRARIES.—At the meeting this week of the members of the Library Association, at Birmingham, Mr. C. J. Woodward read a paper in which he explained some experiments he had made as to the influence of gas on bindings. The conclusions he drew were that leather exposed to the foul air in which gas had been burning for 1,077 hours was seriously deteriorated, for the extent to which it would stretch was reduced from 10 per cent. to 5 per cent., while the strain it would bear was reduced in the ratio of 35 to 17, or about two to one. The leather exposed to a temperature of 195deg. F. for 1,000 hours in an atmosphere free from products of gas combustion was also deteriorated, for the extent to which it would stretch before breaking was reduced from 13 per cent. to 9 per cent., while its breaking strain was reduced from 36 to 28. A temperature of 142deg. F. for 1,000 hours had no marked effect upon leather.

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COMBINED GAS ENGINE AND DYNAMO PLANT.

We are indebted to Messrs. Crossley Brothers for the accompanying blocks illustrating two different arrangements of combined "Otto" gas engine and Crompton dynamos, which are now on view at the Manchester Exhibition. Those who have seen this plant at work at Manchester will have been struck with the extreme steadiness of running which has now been attained in these engines. By combining the dynamo with the engine it is obvious that not only is space saved, but the cost of foundations is less, and the working strains can be better distributed. Fig. 1 represents a 4 horse-power "Otto" engine, capable of indicating 8 horse-power, and a dynamo capable of filling forty-five to forty-eight 16 candle-power lamps. A large jockey pulley, carried on a very substantial liner, is used to lighten the belt, and for starting purposes it is easy to slack the belt a little and to bring it up to its work gradually.

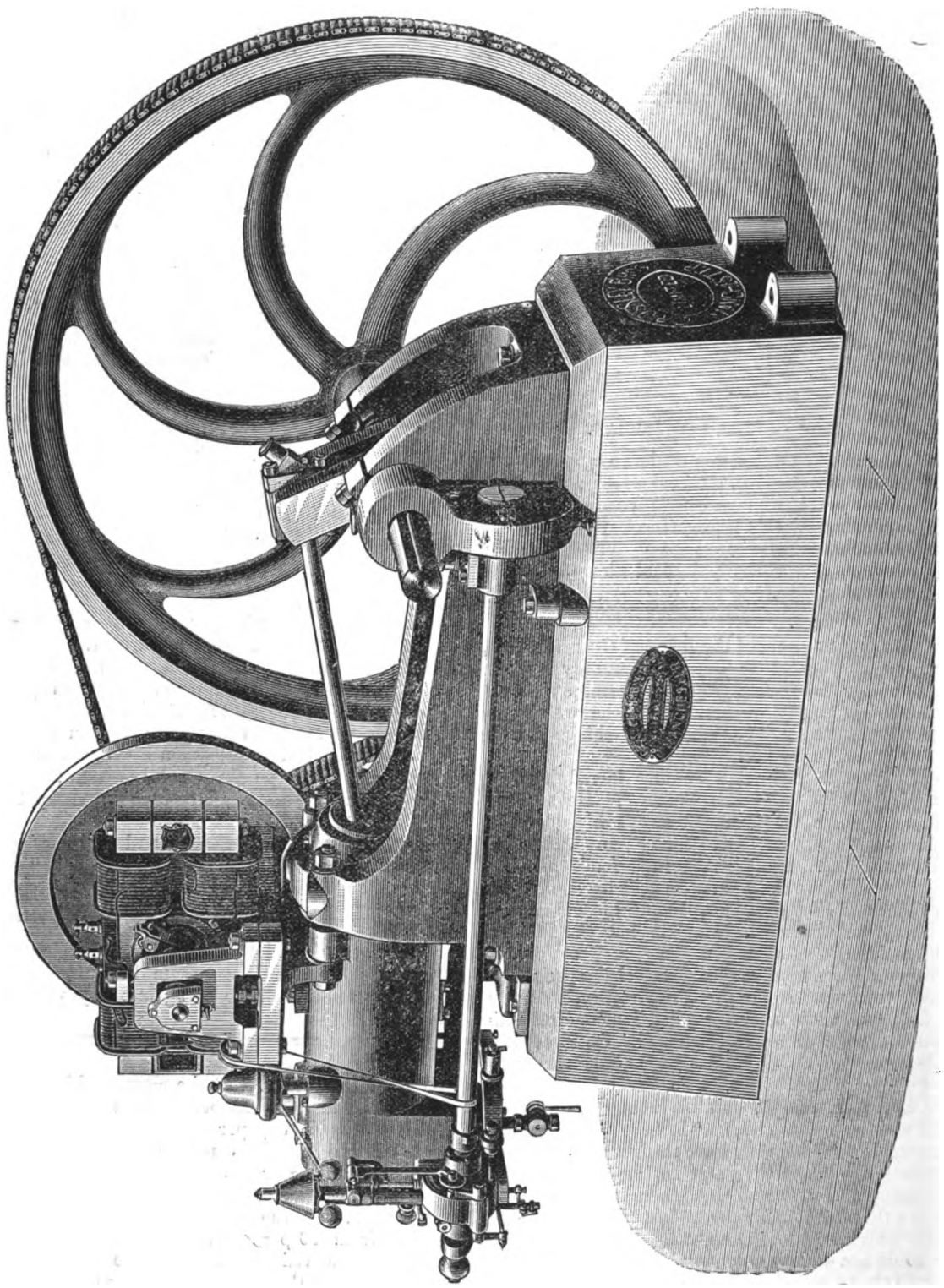

FIG. 1.—Crossley Bros.' Combined Gas Engine and Dynamo.

Fig. 2 is a 1½ horse-power vertical engine indicating 3 horse-power, with dynamo fixed on frame at foot, and is capable of

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running eighteen 16 candle-power lamps. Other sizes of engines, such as the ½ horse-power indicating 1½ horse-power, are supplied similarly combined with dynamos.

AN ELECTRIC CURRENT METER.*

BY PROF. GEORGE FORBES, F.R.S.

At the present moment the mind of electrical engineers is much directed to the successful means of distributing electricity to a large district from central stations by means of that class of induction apparatus which has received the several names of "secondary generator," "transformer," and "converter." This is the only thoroughly worked-out system available to the engineer for an extensive supply of electricity. Currents of an alternating character (*i.e*, alternately positive and negative in direction, the alternations being at the rate of some hundreds per second of time), and of high tension or pressure, are by this system carried from the engine house, by comparatively thin and cheap wire conductors, to the points of supply. The only difficulty which has been met is in the designing of a suitable meter. There is absolutely no meter available that pretends to be reliable. The very best indicates a totally different result when the same current is passed through it, if the number of alternations of the current (*i.e.*, the speed of the dynamo) be altered.

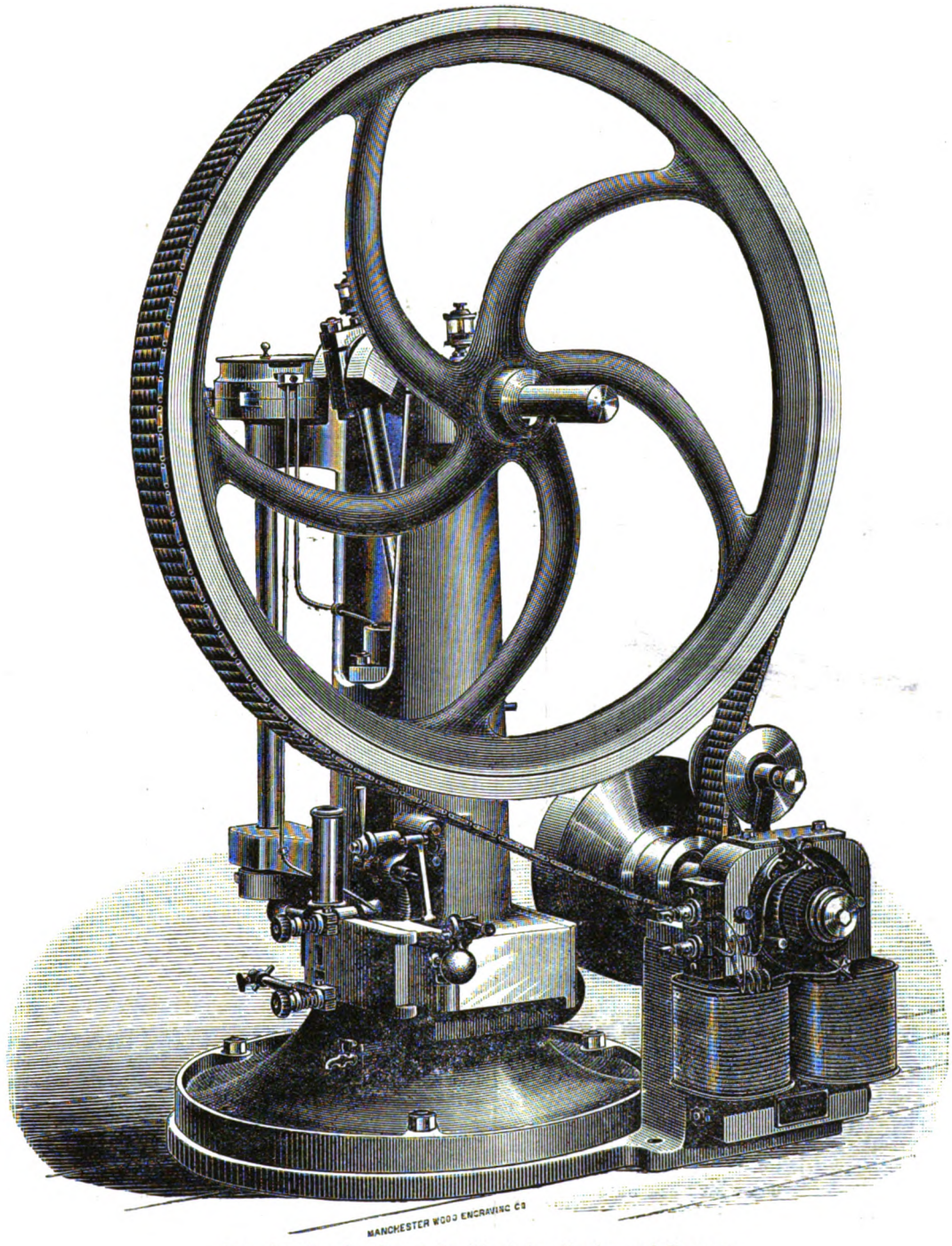

FIG. 2.—Crossley Bros.' Combined Gas Engine and Dynamo.

It was to overcome this source of trouble and to remove the last difficulty from an otherwise perfect system of electric distribution that the author undertook the labour of designing and perfecting the meter here described. Some idea of the work expended in bringing it to its present state of perfection will be gained when it is stated that the trial observations during the development of the instrument number nearly 10,000.

* Paper read before the British Association Meeting at Manchester, September, 1887.

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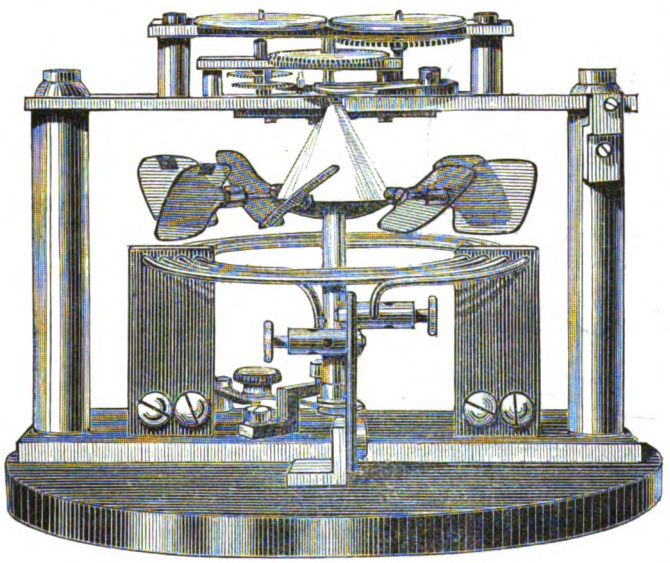
Seeing that the only electrical actions available were those of chemical action, electro-magnetic action, and heat, that the chemical method is incapable of being used with alternate currents, and that all electro magnetic meters must vary in their indications with the rapidity of the alternations, the author was led to base his instrument on the heat developed by an electric current. Such an instrument must be equally applicable to continuous currents and to alternate currents, whatever their rate of alternations. Thus a meter is obtained which is practically perfect and more simple in construction than any of those designed for a more limited range of uses.

The instrument is extremely simple both in principle and in construction. It consists essentially of a flat spiral of iron wire with two terminals. Sometimes these two terminals are united to form one, the other being attached to the middle of the wire. Thus the instrument exhibited may be used as an accurate measure for currents from half an ampere or from one ampere upwards.

Above the conductor a set of vanes is pivoted. This consists of a circular disc of mica with a hole in the centre, in which is fixed a pinion with a concentric ruby cup. Round the circumference of the mica disc eight small cylinders of pith are fixed at equal distances, and eight vanes inclined at 45deg. to the mica discs are attached to the pith cylinders, these vanes being made of the thinnest mica. This set of vanes is supported with the ruby cup resting on a steel point fixed to the base of the instrument. The pinion engages with the first wheel of a train of clockwork actuating the indices, which show upon two dials the number of revolutions made by the vanes.



Prof. Forbes' New Electric Current Meter.

The action of the instrument is very simple. The electric current passing through the iron conductor creates heat, which sets up a convection current in the air, and this causes the vanes to rotate about the vertical axis and drive the clockwork. The number of revolutions indicated on the dials is, through a considerable range of currents, an exact indication of the number of coulombs or ampere-hours which have passed through the conductor. The friction of the ruby cup on the pivot determines the smallest current which can be accurately measured, and the friction of the clockwork is imperceptible.

The following table shows the performance of one of these vanes. The conductor used had a resistance of 0·1 ohm; the first line shows the rate at which the current was flowing through the conductor; the second line gives the ratio of current to speed of rotation, a ratio which ought to be constant :—

Current in amperes	·25	·35	·45	·6	·75	1	2	3	6	12
Ratio of current to speed	76	61·25	50·4	51	50·75	51	51	50·7	51	51·6

When using higher currents the ratio is equally constant.

DISCUSSION.

The CHAIRMAN (Sir F. Bramwell) : The Board of Trade unit is what this meter shows. We have here a most simple form of instrument, which lends itself to the recording of the quantity of electricity used when alternating currents are employed, a difficult problem, which, as Prof. Forbes has told us, his instrument, as simple in construction as a smoke jack, has solved. It really is a smoke jack over electric power.

Sir WM. THOMSON : I have very great pleasure indeed in congratulating Prof. Forbes. Every one who knows anything about electricity understands perfectly that the want of a meter is one of the greatest practical wants in connection with the introduction of central station lighting. I speak feelingly on the subject, for I have tried year after year to produce a meter. There is nothing to which I have given up so much time in endeavouring to make an instrument work as in endeavouring to produce an electric meter, and the Patent Office contains records of some of my attempts. Each one of them has been to some degree capable of giving a result, and the last of them, which I worked at a very great deal till four months ago, promised considerable accuracy, and was perfectly available for either direct or alternate currents. But the difficulty of seeing a way to bring this instrument out, and to make it a practical thing, at a moderate cost, for general use, was so great that I do not feel that I intend to go on with it at all. It is just possible that I might make it succeed as a meter for a larger station. But I am exceedingly glad to see the great success which Prof. Forbes has obtained. I think I may say I am untinged with any feeling of regret at its having been done by another. On the contrary, it is with the most unmixed feelings that I say I am exceedingly glad, and that Prof. Forbes is to be congratulated. With respect to one scientific point raised by what Prof. Forbes has said, we must not be too confident of escaping absolutely in an alternate current meter the effect of different speeds of the engine. Every kind of measurer of alternate currents is affected by different speeds of the engine. In my alternate balance of alternate currents I found it necessary to divide the conductor into thin wires insulated from each other by cotton or silk in order to compel the current to be distributed through the different parts of the conductor equally. In a meter founded upon alteration of temperature a similar effect would hold. If in a thick copper or iron strip, such as would be used by Prof. Forbes with high currents, the self-induction acts so as to sensibly impede the current—if the impedance by self-induction is comparable with the speed of resistance—then Prof. Forbes will be subject to the same difficulty as others. Still I think that in his case the difficulty of practically avoiding effects of self-induction will be much less than in any instrument founded on electro-magnetic force. I am glad to find that Prof. Forbes has with so simple an instrument obtained so perfect a solution of the problem as the numbers he has placed before us prove, and I congratulate him most heartily upon the result.

Prof. PERRY : One has no right to ask an inventor of such a beautiful instrument as this by what means he arrived at the idea embodied in it. I could not have imagined that he could have got this result. The figure certainly shows that it is a beautifully simple instrument, and effects its purpose well. But how any one could arrive at such a method from any theoretical information passes my understanding. The whole action seems to be so complicated. I do not think I should have tried it if the idea had come into my head. I suppose one must miss a tremendous lot of valuable things in this way, because one does not see the theory. I certainly think it is one of the most beautiful things we have had before us for a long time. I speak now as an inventor of a meter which is in considerable practical use, not in this country, unfortunately, but in Germany. That is also a very simple one, but I think that this beats it.

Prof. SILVANUS S. THOMPSON : As another who has tried the invention of a meter, I feel disposed to congratulate Prof. Forbes most heartily on his extremely beautiful and simple solution of the difficulty. I only wish to ask one question, and that is whether this meter, in integrating the various quantities that pass through it, integrates the mean square of the current or the square root of the mean square ?

Mr. A. P. TROTTER : May I ask if the size of the cover has any effect upon the speed of the rotation. Starting with air cold it gets warm with current, and then has to be cooled in order that the rotation may be kept up. I would also ask how much work is absorbed in turning the clockwork, which is the only work it has to do, I suppose.

Mr. R. P. SELLON : I should like to ask Prof. Forbes if he has tried the difference of rotation in the vanes, the difference in the speed of indication for a given current when the air in the chamber is at atmospheric temperature, and again when the meter has been run for some time? as it appears to me that possibly even a small amount of heat given off from the heated wire may, after a certain length of time, raise the temperature of the whole of the air within the chamber.

Mr. F. R. UPTON : At what percentage of the rated capacity of the meter does it start ? That is, after standing for some time. I should also like to ask, if the clockwork which the meter is now turning is without oil and running dry, how much retardation that would cause ?

Mr. LAW asked whether the speed of the meter was affected by the external temperature of the atmosphere.

Prof. BLYTH asked if any irregularity had been observed in the instrument when exposed to all sorts of heat, and whether there was any trace of alteration with the rise and fall of the barometer.

Prof. FORBES, in replying, said that the gentlemen who had asked the questions were really undertaking the whole of the inquiry which he had gone through. It reminded him of the different things that cropped up in the course of the inquiry, and of the way in which they had to be met and the gradual development of the instrument. He would take the remarks of the different speakers in their order. In the first place he wished to tell Sir William Thomson that he sincerely felt the kind way in which Sir William had referred to him, and he was very glad that that gentleman seemed to appreciate the instrument which he submitted to

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the section. He felt honestly that it was really a good instrument. Sir William spoke about the self-induction and the effect of the unequal distribution that went on in the interior of the wire conductor during the time that an alternating current was passing through it. He (the speaker) confessed that when he got the meter pretty fairly into working order it was with some trepidation that he took it to the alternating current machine and began to make tests. His mind was full of the recollection of the experiments on self-induction which Prof. Hughes had brought before them 18 months before, and which he (the speaker) had followed up in prosecuting the work of Prof. Hughes, and he felt then that probably there would be a great difference in the distribution. He found, however, that an alternating current did not introduce an apparent resistance in the same way, certainly not to the same extent, as a suddenly made and broken current did, and that really in the experiments he had made with the alternating current machine he could not perceive the slightest difference in the effects, whether it was with an alternating or a continuous machine, or at whatever speed the alternating machine was running Prof. Perry could not see any theoretical reason why the instrument should work. That showed that Prof. Perry knew a great deal more about it than the speaker did when he began experimenting. Then it seemed to him perfectly evident that it must work—that it must be suitable for all currents—that the speed would be proportional to the current, owing to the fact that the resistance of air friction was proportional to the square of the velocity, and owing to the fact that the motive power which was created was proportional to the square of the current. They had known for many years that these two circumstances ought to make the velocity of the air current an exact measure of the quantity of electric current that passed through the conductor. To his astonishment it was not so in the first meters that he made. He corrected that gradually, however, and ultimately evolved this difficult instrument—which he thought must be perfect, but which Prof. Perry thought ought not to be perfect. Prof. Perry perhaps was right and he was wrong. Mr. Trotter asked a question about the size of the cover. Undoubtedly the size of the cover made a very great difference. If he enlarged it from one size to another he was able to start with a lower current. The size made a great difference in the minimum current which would start the instrument, for there was a difference of speed with the clockwork on than without it. It was, however, almost imperceptible when it was really in working order, but there was a slight difference in the starting with the clockwork on.

Sir FREDERICK BRAMWELL suggested that "wheelwork" might be a better term than "clockwork."

Prof. FORBES thought it would be, inasmuch as some people might be led into the belief that there was a clock attached to it, which was not the case. With the wheelwork attached it depended very much on the delicacy of the construction of the instrument. He had tried not to construct this instrument too delicately, and the practical instrument which he had been speaking of had no jewelled holes in the wheelwork, and could be made at a pretty moderate cost. The instrument shown was started with one half the current that would be required if he took off the wheelwork, but he had made meters in which it was much less. The principal friction was in the jewelled cup resting on the pivot. The wheelwork friction was very much less. Mr. Sellon asked whether there was any variation in the instrument due to atmospheric temperature and again after it had been running some time. There was none. There was a period in the early stage of the instrument when it had a serious influence on it, but with its final development there was absolutely no difference whether it was running for a long or a short period. For the first five minutes or so it took a little time to get up its full speed, so likewise it took a little time to slow down, but for all practical purposes he thought both these conditions balanced each other. It was a mere trifle in any case. In reply to Mr. Upton, the speaker explained by means of a diagram when the instrument commenced to rotate, and other details. The meters he had spoken of were supposed to be made for thirty lamps, and to indicate one lamp with fair exactness; but it would start with one half of that which was required for one lamp Another gentleman asked whether the external temperature of the atmosphere or any barometrical influence affected it, and whether there was any barometrical correction necessary. In fact, nearly every person had asked him that question. It did not, and that was about the only part of the meter in which practice agreed with theory. It was a very curious thing, but it seemed at first sight as if a higher temperature ought to make a difference; but when they remembered that the motive force was the difference of temperature in the neighbourhood of the conductor and the external air, and not the absolute temperature of the wire, they would see that it did not matter whether the external air was 50deg. or any other figure. As to barometric observations, he had made no tests to see whether there was any difference with variations in the barometer. He had tried the same instrument for long periods of time without finding any difference of the constant, and he was practically certain that the barometrical changes to which they were subject did not introduce changes in the meter. Since he had introduced the spiral conductors he had never had the slightest difficulty.

Sir FREDERICK BRAMWELL said it was needless for him to occupy the time of the section longer, but he would like to say that they must recollect that there were two things needed before the meter became commercially useful. The first was that they should be allowed to use it without any restraint from anybody, and the other was that in using it they should have the means of charging to the consumers the amount of electricity that was supplied to them. Prof. Forbes, he thought, had shown that he had invented a meter most simple in its principle and mode of action, and one that would truly indicate within such limits as were attained in gas meters (and they ought to desire nothing more) the amount of electricity which any person would have to pay for when they had succeeded in getting rid of those unfortunate restrictions which now prevented the supply of electricity from central stations.

FAST-SPEED TELEGRAPHY.*

BY WILLIAM HENRY PREECE, F.R.S.

In this Jubilee year of telegraphy many papers have been read, articles written, and speeches delivered on the progress made during the past 50 years, scientifically, practically, and commercially, but with very few exceptions has any justice been done to the advance made in England in the scientific direction.

Sir William Thomson said, "You have told us how splendidly the land telegraphs are worked; you have pointed out how admirably under the influence of the Government system the application of science to telegraphy has been developed Under Government management within these last seventeen years the applications of science to telegraphy have not stood still, but, on the contrary, have been pushed forward with every possible energy and with the most marvellous success."

I want to describe the evolution of the system of high-speed telegraphy since it left the hands of Wheatstone and Mr. Stroh.

The following table illustrates the progress made:—

Year.	Words per minute.	Speed to Ireland.
1870	80	50·3
1875	100	70
1880	200	150
1885	350	250
Now	600	462

These results have been the consequences of—

1. Greater perfection of apparatus.
2. The elimination of electro-magnetic inertia.
3. The improvement of circuits.
4. Introduction of high-speed repeaters.

Two reasons exist why these great advances have not received notice; they were not patented, and they emanated from Government service. A patent has certainly one great use, it fixes a date and it defines an invention, but it also attracts attention to novelties and improvements, and if the patent be lucrative it incites the immoral to try and do the same thing in another way, which tends to litigation, though often resulting in still further improvements. There is a very ridiculous conception abroad and widely circulated, that commercial enterprise alone is competent to excite inventive skill. I have more than once contested this proposition, but with very little effect, for from the floor of the House of Commons, and from the columns of the press, there is the same cold indifference to the work done in Government departments, and the same cry as tersely put by *Nature*, "The feeling is 'What good can come out of Nazareth?'"

A complete set of automatic instruments consists of

1. The *perforator*, which punches a strip of paper with holes on the principle of the Jacquard loom, so as to regulate the number, order, and rate at which alternate currents of electricity are sent along a wire by

2. The *transmitter*, which is the automatic part of the apparatus, sending along the line those currents which at the distant end are recorded as words in the form of dots and dashes, replacing the slow and uncertain manipulation of the hand.

3. The *receiver*, which is an ink-writer of extreme delicacy and great rapidity, recording the words in the Morse character.

1. The perforator has not been much modified since it left the hands of that accomplished mechanician, Mr. Stroh. Experience has brought out several mechanically weak points, which have been much simplified and strengthened. They have been made to a standard gauge, both as regards the number of perforations per foot,† the strength of springs, and the uniformity of parts, so that interchangability is possible throughout the whole service. The fact that air pressure for working pneumatic tubes exists in many large post offices besides London has led to its application to punching, which

* Paper read before the British Association Meeting, Manchester, September, 1887.

† The standard is 120 centre perforations per foot, or, counting the first and last perforation, 121 centre perforations per foot.

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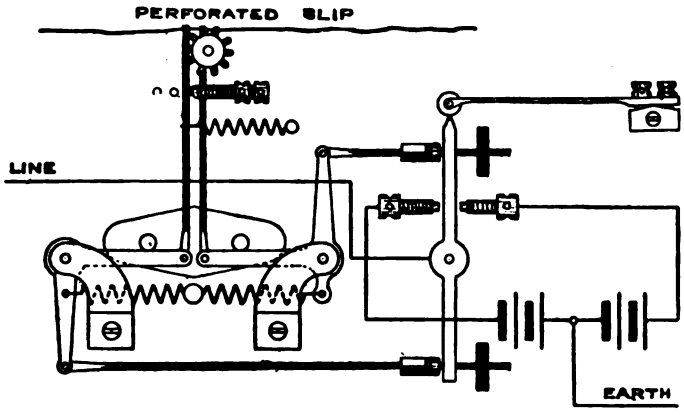
is rather a severe mechanical labour, and it has rendered it possible by constructing double-banked perforators to punch eight slips at one time, an invaluable reduction of labour in the transmission of news which has grown to such gigantic proportions that frequently over 1,000,000 words have been sent in one evening from the Central Office in London.

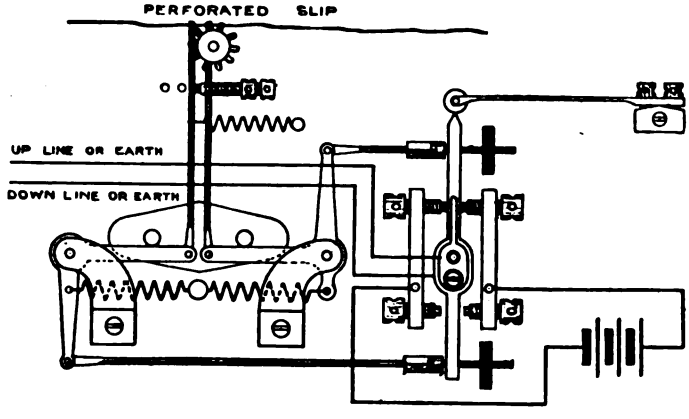
2. The transmitter is an instrument designed to send as many reversals of current per second through the line as the retardation and the electro-magnetic inertia of the circuit will allow. These reversals are rapid alternations of positive and negative currents, the former making dots and called the marking currents, the latter making spaces and called the spacing currents. When the transmitter runs free without any paper to guide it, these currents flow through the line with a regular frequency which is controlled by a beautiful excentric governor invented by Mr. Stroh. This frequency in the present transmitter can be regulated from 14 up to 240 reversals per second, which means 600 words per minute.

FIG: 1.



When unpunched paper is inserted a permanent current goes to line, the motion of the electrical contact that reverses the current is checked or hindered; when the paper is punched then a dot means a complete reversal, a dash means three complete reversals, but the middle one checked by the paper; a space means three complete reversals all checked by the paper. In the earlier form of transmitter the reversal was effected by a commutating arrangement which involved time, and which could not exceed a frequency of 48 or 120 words per minute. It was a very rapid double current key using one battery. In 1883 this plan was revised, a double or divided battery was used, earth being in the centre, the contacts being simple butt contacts.

FIG: 2.

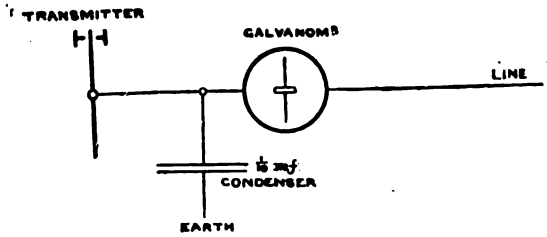


The mechanism was thus very much simplified, and the possible speed of working increased to a frequency of 120 or 300 words per minute. Subsequently, in 1886, the divided battery was rendered unnecessary by a new form of contact of the same character, but requiring only one battery, and the possible frequency was increased to 240, or a working speed of 600 words per minute.

It is evident that with such rapid working the accuracy and perfection of the workmanship must be chronometric in its character. All automatic apparatus is made in the department's own workshops, where mechanicians of the highest skill are employed, where standard gauges are carefully worked up to, and where the most rigid system of inspection is exercised.

One source of trouble has been sparking at the points of contact, which dirties them by disintegrating the metal. Small condensers of $\frac{1}{10}$ microfarad capacity have been applied thus:

FIG: 3.



which considerably modified the evil; but it has been still further reduced by switching out the galvanometer while the transmitter is at work, for sparking is principally due to the presence of electro-magnetic inertia in the apparatus.

3. The receiver has been entirely remodelled both mechanically and electrically. The principal mechanical improvement has been replacing a spring as a motor by a weight in order to secure a more rapid and more uniform rate of running at high speeds, and as a receiver may at one moment have to record at 400 words per minute and the next at 25 when working by hand, it is clear that unless some governor be used the waste of paper would be excessive.

Improved flies have been applied to Stroh's excentric governor so as to make it act with equal efficiency at the present high speeds. Thus, the length of the signals made and the length of paper used per twelve words is practically the same at high and low speeds.

It was thought at one time that the speed of working was limited by the retardation of the line circuit, but a careful inquiry into the phenomena of electro-magnetic inertia (*Journal* of the Society of Telegraph-Engineers, 1877, Vol. V., page 27) led me to the conclusion that the principal source of slowness was in the electro-magnet. It is not possible, owing to this electro-magnetic inertia, to establish *instantaneously* through a circuit containing an electro-magnet a current of the strength due to the electromotive force producing and to the resistance regulating it. The current strength can be brought up only gradually to its proper value.

Every electro-magnet in a telegraph wire becomes an obstruction to the flow of currents, especially when these currents are rapidly intermittent or rapidly reversed. In telegraphs they lower the speed of working, in telephones they blurr the clearness of articulation. It is as though the passage for the flow of electricity were restricted, as the clear way of a water pipe would be choked by the presence of a large stone in the pipe, or the efficiency of a gas pipe would be reduced by its being crushed in by a blow from a hammer. But the peculiarity of the electro-magnet is that the currents themselves cause their own hindrance, and the more frequent they are the greater the throttling or choking action. The action is not dissimilar to that of the throttle valve of a steam engine actuated by a centrifugal governor. Hence, Lord Rayleigh has lately proposed to apply the term "throttling" to this peculiar effect of electro-magnetic inertia. Every electro-magnet has thus a time constant which determines the rate beyond which it cannot work. This time constant can be obtained only by experiment, for it depends on the quality and quantity of iron used, on the form of the core, on the resistance and quality of insulated copper wire, on the number of turns, and on the

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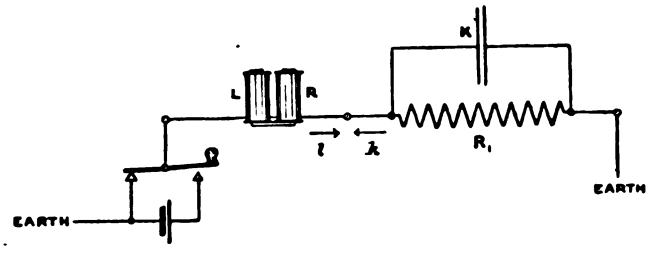
way they are wound. The battle with self-induction has been a severe one. Years of labour were devoted to determine the proper conditions to reduce these disturbing elements to their minimum point of hindrance combined with efficiency, until fortunately a means was discovered to entirely eliminate their influence.

Every electro-magnet wound to a resistance R has its own coefficient of self-induction L, which determines the rate at which a current rises or falls, and the time constant is expressed by the ratio $\frac{L}{R}$. It is the time the current takes to rise from zero to its full value.

If the two plates of a condenser of capacity K be shunted by a wire of resistance R_1, then when a current flows the condenser will be charged and the current will consequently gradually rise to its full value, and if the current stops the condenser will discharge and the current will in the same way gradually fall to zero. The time constant of such a condenser is KR_1. This is exactly the same kind of action that takes place in an

FIG. 4.



electro-magnet, and by properly regulating the size of the condenser and the amount of resistance the one can be made to exactly reproduce the former.

Now, if we connect up an electro-magnet and a condenser in the way shown in the following diagram, then, whenever the main current ceases, there is an electromotive force in the magnet due to L, tending to prolong the current in the direction (*l*), while there is an E.M.F. in the condenser K due to the charge tending to do the same thing, but in the opposite direction (*k*). Hence, these two effects oppose and neutralise one another when the resistances R and R_1, the coefficient L, and the capacity K are properly adjusted.

Maxwell has shown that when an electro-magnet and a condenser are balanced in a Wheatstone bridge, $L = R R_1 K$, but in the shunted arrangement (as shown in appendix),

$$L = R_1^2 K.$$

The introduction of the shunted condenser has had the most marvellous effect on the speed of working. It has entirely eliminated any hindrance caused by the electro-magnet, and now the only cause of slow working is the mechanical efficiency of the apparatus and the condition of the circuit. I have pointed out in another paper how copper wire has removed electro-magnetic inertia from the wire, and there remains only the retardation (KR) of the circuit to check speed of working.

Four hundred and fifty words a minute is now obtained with ease on circuits of 200 miles in length, and we have on some circuits reached 600 words per minute; but 450 is more than we can practically cope with, and, therefore, at present the apparatus exceeds in efficiency the capacity of the staff; but this speed rapidly falls off as the retardation of the circuit increases, and while we can work at the highest speed between London and Leeds, we can only get one-fourth of this speed to Glasgow. If, however, we place at Leeds a repeater, which will respond to and relay on these frequent currents, we ought to get the maximum speed to Glasgow, and this is done by the high-speed repeater. The high-speed repeater contains on one board all the electrical functions of two transmitters and two receivers. All causes of hindrance are removed from it, and it works at the highest possible speed. Electrically it is an exceedingly complicated piece of machinery. It owes its efficiency to the perfection of the Post Office standard relay—a relay which has practically no time constant, which responds to exceedingly delicate currents, and which makes perfect electrical contacts—and to the use of condensers.

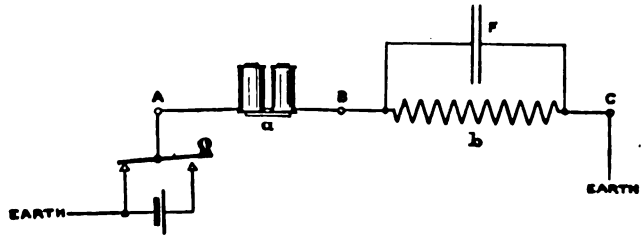
These repeaters are very extensively used. There are special relay offices at Haverfordwest, Nevin, and Anglesey to provide full speed to Ireland. The speed to Ireland in 1870 was 50 words per minute. It is now 462 words—a ninefold advance. Leeds, Manchester, Bristol, and Preston have also special relay rooms. There are 101 repeaters in use. Some circuits, such as those to Aberdeen, have two repeaters in circuit, one at Leeds and the other at Edinburgh. In fact, these high-speed repeaters enable the highest possible speed of working to be obtained to every part of the United Kingdom. They are arranged so as to be used at will either for automatic or for ordinary key apparatus, and either for simple or for duplex working under each class of working.

The introduction of high speed repeaters and the use of shunted condensers have marked epochs in the evolution of telegraphy as eventful as the introduction of duplex working or of the telephone. The various stages of improvement which have been narrated in this paper would each form the subject matter of a patent were it the habit in the Government service to patent. Had the telegraph service been conducted under the severe competition of private enterprise, each form of transmitter and of receiver, the relay, the high-speed repeater, the shunted condenser, and every other improvement would have been patented, and would have been found worthy of substantial reward.

I may add that in bringing about these improvements I have been most ably assisted in the mechanical department by Mr. J. W. Willmot, now the head of our workshops, and in the electrical department by Mr. J. B. Chapman and Mr. A. Eden, both accomplished practical electricians.

APPENDIX.

FIG. 5.



If E be the E.M.F. at any moment taken between A and C, e_1 that between A and B, and e_2 that between B and C, also if *a* be the resistance between A and B, *b* that between B and C, then

$$E : e_1 :: a+b : a$$
$$E : e_2 :: a+b : b$$
$$e_1 = E\frac{a}{a+b},$$
$$e_2 = E\frac{b}{a+b}.$$

The quantity in condenser is

$$Q = e_2 F = EF\frac{b}{a+b},$$

and that discharged from condenser through *a* is

$$q_1 = Q \cdot \frac{b}{a+b} = EF\frac{b^2}{(a+b)^2}.$$

Again, the quantity discharged from the magnet is

$$q_2 = L\frac{E}{a+b} \cdot \frac{1}{a+b} = EL\frac{1}{(a+b)^2}$$

But $q_1 = q_2$

$$EF\frac{b^2}{(a+b)^2} = EL \cdot \frac{1}{(a+b)^2},$$

or

$$F b^2 = L.$$

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DISCUSSION.

The CHAIRMAN (Sir Fredk. Bramwell), in opening the discussion, said they would agree with him that it should not be allowed to branch off into a question of the expediency of patent laws, notwithstanding the temptation thrown out by Mr. Preece to do so. He did not say that it was not a subject very much within the competence of Section G, though it was rather more suitable for Section F. But there was a more important scientific side to the subject, which many gentlemen present were quite able to discuss.

Sir WILLIAM THOMSON, who said he had not been present to hear the whole of the paper, congratulated Mr. Preece upon the great success which had been attained under his management in the practical work of telegraphy in the United Kingdom. The figures he had put before them were really of a most remarkable kind. One question with reference to the 600 words a minute which he would like to ask was whether they were all sent in one direction, or in both directions at the same time? He gathered that it was the whole of the work done on the wire in two directions at once. He should be very glad to hear that a speed of 600 words all told in both directions was attainable.

Mr. PREECE: They are all in one direction.

Sir WILLIAM THOMSON: And is the instrument capable of being worked 300 words in one direction and 300 in the other, or only in one direction?

Mr. PREECE: Only in one direction. I have made no reference to duplex working. We have found when working duplex that we can only get half the speed in each direction, so that if we were working at 600 we could only get 300 words in each direction in the minute.

Sir WILLIAM THOMSON said he was thinking of the very beautiful system of Delany which was now in use. But he understood that this was the Wheatstone instrument, and worked in one direction only. They would all, he was sure, be glad to hear one word from Mr. Preece as to whether the Delany system had come into considerable use since he explained it to the section last year.

Mr. PREECE said it would be a great gratification to him if he knew from Sir William Thomson that he had explained the action of the shunted condenser.

Lord RAYLEIGH observed that he was very much interested in Mr. Preece's description of recent progress in the matter of telegraphy. He had really no knowledge of it himself, but there was just one reference that he would like to mention, which he thought many practical telegraphists did not know about, although some scientific electricians did, and that was the paper that appeared some years ago in the *Transactions* of the Edinburgh Society, by Chrystal, who discussed in considerable detail a large variety of arrangements such as that to which Mr. Preece had called their attention and the relations of electro-magnets and resistance condensers, investigating very fully the electrical property involved. No doubt the property used in this particular arrangement was set forth in that paper. One question which it occurred to him to ask Mr. Preece was if he could give them some comparison between the fast-speed rate of telegraphy and the highest rate to be attained by telephony. That would probably convey a definite idea to the minds of many present.

General WEBBER said there was one point which he thought would be very interesting to the meeting to hear from Mr. Preece, and that was the number of individuals that it was necessary to employ at each end of the circuit worked in this way so as to obtain from it its full capacity of 600 words per minute.

Prof. PERRY had nothing to say upon the paper, except to make a reference to the scientific description—the exact mathematical description—of the negative effect which a condenser shunting a resistance had. The condenser acted as a negative self-induction. Mr. Preece's popular description was of considerable value, but the exact mathematical description, very simply put indeed, would be found in a paper by Mr. Sumpner, recently published in the *Journal* of the Society of Telegraph-Engineers and Electricians.

Mr. KAPP asked whether this was the only arrangement of a shunted condenser in use, or whether in some cases Mr. Preece put the plates of the condenser to the terminals of the electro-magnets, which would, he believed, act in the same way, though perhaps it would not do exactly what this arrangement did for telegraphy.

Mr. FAULKNER wished to know whether Mr. Preece had found any difference in speed when using a common electro-magnet and when using a Faulkner altandi magnet.

Mr. TROTTER put a question—which he thought any telegraphist would probably know—how many separate impulses were meant by 600 words a minute? How many letters went to an average word, and about how many impulses to a letter?

Mr. SNELL asked whether the capacity of the condenser required adjustment when working at different rates of speed, or whether the capacity would remain constant, and give sufficiently good results at very different rates of working.

The CHAIRMAN said Mr. Preece would in his reply perhaps touch upon the question put by Sir William Thomson, although it really formed no part of the present paper.

Mr. PREECE: Sir W. Thomson asked a question about duplex working, and I think I answered it at the time, but I will again refer to this point, because it is scientifically an extremely interesting one indeed. We have found—taking the line from London to Dublin, which I have still in my mind—that with a shunted condenser arrangement, and all the latest improvements, the highest speed that it has been possible to get out of the circuit has been 462 words per minute. That shows that the speed is not limited by the apparatus used, but by the circuit. We found that working duplex on the same circuit we got 231 words a minute each way, showing that the speed of 462 words a minute was obtained by utilising every impulse that could be passed through the circuit, and that when we revert from simple to duplex working, we can only utilise the number of reversals or simple currents. Before we reached this limit it was a common thing to find that the sum of the two working duplex was smaller than working single, and that we had not reached the maximum efficiency of our circuit. But now these experiments between London and Dublin have quite satisfied me that at the present moment we are getting out of our circuit all that it is possible to get out of it. But it is a case of "Never say die!" All the work of the last year has shown that there is room for improvement. With reference to what Lord Rayleigh has said, I may say that the sole reason why we have so persistently pegged away at this high-speed working has been the fact that the telephone has been brought out, and that it is possible to get a number of impulses through a circuit infinitely greater than was thought possible before the telephone was introduced. Our eyes have been opened enormously by this beautiful and simple telephone apparatus. I read last year before the Royal Society a paper upon this subject, showing that the law regulating the distance to which we can speak by telephone is precisely similar to that of Sir Wm. Thomson regulating the number of reversals that pass through a current. I am afraid that many of my friends are not quite satisfied that I have made my case very clear or strong, but if I have not done so it has been from my inability to do so. But I am perfectly certain of this, the more they study the subject, the more they work with a high-speed current and telephony, the more surely they will find that there is practically no difference whatever between the current used for telephonic purposes and those used for high-speed telegraphy. Sir William Thomson asked about Delany. The Delany apparatus is another advance in telegraphy in another direction and for another purpose. We ordinarily work a telegraph simple, or simplex—that is, one message in one direction in one time; duplex working means two messages going in opposite directions at the same time; quadruplex means four messages in opposite directions at the same time, so that four messages are passing through a wire simultaneously. But the Delany multiplex has enabled us to send six totally different messages through the same wire at the same time. These messages need not be in reverse directions; all may be in one direction, or one in one and five in another, or they may be mixed up in any combination of six. Sir William Thomson will be glad to hear that we are developing this system very fast indeed. We are I think improving it. We find great difficulty in surmounting the effects of the capacity of our wires, but we are now working from London to Birmingham, from Birmingham to Manchester, from London to Manchester, from London to Leeds, and from Leeds to Carlisle, and this week we are working from London to Glasgow, with repeaters at Leeds. In the last paragraph of my paper I have referred to the assistance I have received in carrying out all these improvements in fast-speed telegraphy from Mr. Wilmott, who is at the head of the workshops; Mr. Chapman, who takes immediate charge of the high-speed telegraph and high-speed repeaters; and especially from Mr. Eden, my assistant here, to whom alone is due the way in which the application of condensers has been so fully carried out. I have only referred here to one use of condensers. They are being used for all kinds of purposes, and the manufacture of condensers is becoming a very important part of my business. Mr. Eden has just returned from Leeds, and he tells me that we have now established between London and Glasgow a Delany multiplex apparatus, with repeaters at Leeds. I hope next year to be able to read a paper upon this subject. Prof. Perry has referred to an extremely able paper by Mr. Sumpner. As a matter of fact, the whole telegraphic world is indebted to Profs. Ayrton and Perry for the way in which they brought the subject of self-induction before the Society of Telegraph-Engineers and Electricians, and their pupil, who developed the subject, showed what admirable means of instruction are to be obtained at the City and Guilds of London Institute if only we send our sons there. Profs. Ayrton and Perry have devised an instrument for measuring this magnetic inertia. I am going to bring the subject before Section A to-morrow, and therefore pass on for the present. Mr. Kapp asked if we had used the condenser as a shunt to the electro-magnet. Of course we have tried that, but, as a matter of fact, if the condenser is used in any other way that shows it acts as a positive, and adds to the retardation of the capacity of the circuit, and has a deterring influence. Mr. Faulkner asks if we have found good results with his magnet. If Mr. Faulkner reads the paper and learns a little more about magnetic inertia he will find that his magnet has a deterring influence rather than a beneficial one on the speed of working. Mr. Trotter asked how many reversals of current there were? Well, it means 240. The frequency is 20 per 50 words, so that if you know the rate at which we are working you get at the frequency at once. When we work at 20 reversals per second it means 50 words per minute.

Sir WILLIAM THOMSON: Ten periods, I understand?

Mr. PREECE: No; 20 periods—20 positive and 20 negative. It is the whole period of the positive and the negative. Mr. Snell asks if we find any variation in the capacity with different speeds. We do not. We find it when working with iron wire, but when working with copper wire at higher speed we find no difference whatever with variation in speed. That is a point I shall refer to to-morrow.

The CHAIRMAN called upon the meeting to accord a vote of thanks to Mr. Preece, and his request was heartily complied with.

STORAGE BATTERIES FOR ELECTRIC LOCOMOTION.*

BY A. RECKENZAUN.

The idea of employing secondary batteries for propelling vehicles is almost contemporaneous with the discovery of this method of storing energy. To Mr. Planté, more than to any other investigator, much of our knowledge in this branch of electrical science is due. He was the first to take advantage of the action of secondary currents in voltaic batteries.

* A paper read at the meeting of the American National Electric Light Association.

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Planté is a scientist of the first grade, and he is a wonderfully exact experimenter. He examined the whole question of polarisation of electrodes, using all kinds of metal as electrodes, and many different liquids as electrolytes, and during his endless researches he found that the greatest useful effect was produced when dilute sulphuric acid was electrolysed between electrodes of metallic lead.

I need not describe the disappointments which followed the first unfulfilled hopes, nor repeat the criticism that was heaped upon the heads of the early promoters. Those early hopes were untimely and unreasonable. A thousand difficulties had to be overcome—scientific difficulties and manufacturing difficulties. The period of maturity has also been retarded by injudicious treatment, but the ultimate success was inevitable. Great advances have been made within the last few years, and I propose now to offer a few facts and figures relating to the present state of the subject with reference to the application of storage batteries to locomotive purposes. It is not within the province of this paper to discuss all the different inventions of secondary batteries, nor to offer any suggestions with regard to priority, therefore I will confine myself to general statements. I am aware of the good work that was done in the United States by Kirchhof 26 years ago, and of the more recent work of Mr. Brush, of Cleveland, Mr. Julien and others, but I am more particularly acquainted with the recent achievements of the Electrical Accumulator Company, who own the rights of the Electrical Power Storage Company, of London. I have used the batteries of the latter company for propelling electric boats and electric street cars. The first of the boats was the "Electricity," which was launched in September, 1882, and which attained a speed of seven miles an hour for six consecutive hours. Since then a dozen electric boats of various sizes have been fitted up and worked successfully by means of storage batteries and motors of my design. The most important of these were the launch "Volta," and another similar craft, which is used by the Italian Government for torpedo work in the harbour of Spezzia. On the measured mile trial trips the Italian launch gave an average speed of 8·43 miles an hour with and against the tide. The hull of this vessel was built by Messrs. Yarrow and Co., and the motors were manufactured by Messrs. Stephens, Smith and Co., of London. The "Volta," which was entirely fitted by the latter firm, is 37ft. long and 7ft. beam. She draws 2ft. 6in. of water when carrying 40 persons, for whom there is ample sitting accommodation. There are 64 cells in this boat; these are placed as ballast under the floor, and actuate a pair of motors and a screw coupled direct to the armature shaft running at 700 revolutions a minute. We crossed the English Channel with this boat in September of last year, leaving Dover at 10:40 in the morning, arriving at Calais at 2:30 p.m.; stayed about an hour in the French harbour for luncheon, and floated into Dover docks the same evening at 6:30 with full speed. The actual distance traversed without entirely discharging the cells was 54 miles, the current remained constant at 28 amperes until 5 p.m., and it only dropped to 25 amperes at the completion of the double voyage between England and France. Several electric launches are now being constructed in London, and one in New York by the Electrical Accumulator Company.

M. Trouvé exhibited a small boat and a tricycle, both worked by Planté accumulators, at Paris, in 1881.

The first locomotive actuated by storage batteries was used at a bleaching works in France in 1882. During the same year I designed an electric street car for the Storage Company, and this was tried on the lines of the West Metropolitan Tramways in March, 1883. It had accommodation for 46 passengers. This car had many defects, and I reconstructed it entirely, and ran it afterwards in its improved form on the South London Tramways, and also on a private track at Millwall, where it is now in good condition, and I have a similar car in Berlin. M. Philippart exhibited a car in Paris and M. Julien made successful experiments in Brussels, Antwerp and Hamburg. Mr. Elieson is running storage battery locomotives in London. M. Julien has also been experimenting with a car in New York, and I believe one is in course of construction for a line in the city of Boston. Messrs. W. Wharton, jun., and Co. have a storage battery car running at Philadelphia on Spruce and Pine streets, and this energetic firm is now fitting up another car with two trucks, each carrying an independent motor, similar to my European cars.

I have mentioned all these facts in order to show that there is a considerable amount of activity displayed in the matter of storage batteries for street cars, and that continued and substantial progress is being made in each successive case. The prejudices against the application of secondary batteries are being rapidly dispelled, and there are indications everywhere that this method of propulsion will soon take a recognised place among the great transit facilities in the United States. I feel convinced that this country will also in this respect be far ahead of Europe before another year has passed over our heads.

There are several popular, and I may say, serious objections to the employment of storage batteries for propelling street cars. These objections I will now enumerate, and endeavour to show how far they are true, and in what measure they interfere with the economical side of the question.

First objection: The loss of energy, which amounts in practice to 20, and sometimes 30 per cent. Now, every method of storing or transmitting energy involves some waste; but in saying this we need not condemn the system, for after all the term efficiency is only a relative one. For instance, a 10 horse-power steam engine consumes three times as much fuel per horse-power-hour as a 1,000 horse-power engine does, yet this small engine must be, and is regarded as, one of the most economical labour saving appliances known to us. Considered as a heat engine the efficiency of the most economical steam motor is but 10 per cent.—90 per cent. of the available units of heat contained in coal being lost during its transformation into mechanical energy. Thus, if we find that the storage battery does not return more than 70 per cent. of the work expended in charging it, we ought not to condemn it on that account until we have ascertained whether this low efficiency renders the system unfit for any or all commercial purposes. It is needless to go into figures in order to show that, when compared with animal power, this objection drops into insignificance.

The second more formidable objection relates to the weight of storage batteries, and this involves two disadvantages, viz.:—waste of power in propelling the accumulator along with the car, and increased pressure upon the street rails, which are only fitted to carry a maximum of 5 tons distributed over 4 points, so that each wheel of an ordinary car produces a pressure of 1¼ ton upon a point of the rail immediately under it.

The last mentioned objection is easily overcome by distributing the weight of the car with its electrical apparatus over 8 wheels or 2 small trucks, whereby the pressure per unit of section on the rail is reduced to a minimum. With regard to the weight of the storage batteries, relatively to the amount of energy the same are capable of holding and transmitting, I beg to offer a few practical figures. Theoretically, the energy manifested in the separation of one pound of lead from its oxide is equivalent to 360,000 foot-pounds, but these chemical equivalents, though interesting in themselves, give us no tangible idea of the actual capacity of a battery.

Repeated experiments have shown me that the capacity of a secondary battery cell varies with the rate at which it is charged and discharged. For instance, a cell such as we use on street cars gave a useful capacity of 137·3 ampere hours when discharged as the average rate of 45·76 amperes, and this same cell yielded 156·38 ampere hours when worked at the rate of 22·34 amperes. At the commencement of the discharge the E.M.F. of the battery was 2·1 volts, and this was allowed to drop to 1·87 volt when the experiment was concluded. The entire active material contained in the plates of one cell weighed 11·5lbs., therefore the energy given off per pound of active substance at the above high rate of discharge was 62·225 foot-pounds, and when discharging at the lower rate of 22·34 amperes the available useful energy was 72·313 foot-pounds, or nearly 2·2 electrical horse-power per pound of active matter. But this active substance has to be supported, and the strength or weight of the support has to be made sufficiently great to give the plate a definite strength and durability. The support of the plates inclusive of the terminals above referred to weighs more than the active material, which consists of peroxide of lead and spongy lead; so that the plates of one cell weigh actually 26·5 pounds. Add to this the weight of the receptacle and acid, and you get a total of about 41 pounds per cell when in working order. Seventy of these cells will propel an ordinary street car for four hours and a-half, while consuming the stored energy at the rate of 30 amperes, or over 5·6 electrical horse-power. The whole set of seventy cells weighs 2,876lbs., which is barely one-fifth of the entire weight of the car when it carries forty adult passengers, therefore the energy wasted in propelling the accumulator along with a car does not amount to more than 20 per cent. of the total power, and this we can easily afford to lose so long as animal power is our only competitor. From numerous and exhaustive tests with accumulators on cars in this country and abroad, I have come to the conclusion that the motive power for hauling a full-sized street car for fifteen hours a day does not exceed $1.75, and this includes fuel, water, oil, attendance, and repairs to engine, boiler, and dynamo. We have thus an immense margin left between the cost of electric traction and horse traction; and the last objection, that relating to the depreciation of the battery plates, can be most liberally met, and yet leave ample profits over the old method of propulsion by means of animals.

The advantages of storage battery street cars for city traffic are self evident, so that I need not trouble you with further details in this respect, but I would beg those who take an interest in the progress of the electric locomotive to give this subject all the consideration it deserves, and I would assure them that the system which I have advocated in this brief but very incomplete sketch is worthy of an extended trial, and ready for the purposes set forth. There is no reason why those connected with electric lighting interests in the various cities and towns should not give the matter their special attention, as they are the best informed on electrical engineering, and already have a local control of the supply of current needed for charging.

DIRECT SPANISH TELEGRAPH COMPANY.

Report and accounts of the Directors for the half year ended 30th June, 1887, to be presented at the general meeting of shareholders, to be held at Winchester House, Old Broad-street, E.C., on Friday, the 30th inst., at twelve o'clock:—

The accounts for the half year show, after providing for debenture interest and a charge for renewal referred to in paragraph 5, a balance to the credit of profit and loss of £4,649. 10s. 3d. The traffic receipts show an increase of £366. 19s. 9d. as compared with the corresponding half year of 1886, when a higher rate of tariff existed than at present. The balance-sheet shows for the first time the capital as reduced in accordance with the order of the Court. Both the Company's cables and the land lines in connection with these have continued in good working order throughout the half year. In the month of February a favourable opportunity occurred of renewing and altering the position of the shore-end of the cable at Marseilles, and of leading a new subterranean land line from the cable landing along a greatly improved route. This renewal was effected by the Eastern Telegraph Company at a very small cost while that company was renewing their own shore ends and land lines. The cost of this renewal has been charged to revenue. The Directors have, in accordance with the policy announced when the reduction of capital was agreed to by the shareholders, put £2,500 of the balance of profit and loss to the reserve fund,

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which now amounts to £5,899. 8s. 3d., and there will then remain £2,149. 10s. 3d. available for dividends. The Directors recommend the payment of the dividend of 10 per cent. on the preference shares, and a dividend at the rate of 2½ per cent. on the ordinary shares, free of income tax, and to carry forward £2. 19s. 3d. to next account.

CITY NOTES, &c.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 15th September are £1,989, as compared with £1,864 in the corresponding period of 1886.

AN ADDRESS.—Messrs. Mix and Genest, of Berlin, whose microphone was recently described in our columns, ask us to state that their address is Neuenburger Strasse 14A, Berlin.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept 21.		Business Done Week Ending Sept. 21. Highest.		Lowest.
Anglo-American	35½,	36½	35½		—
Do. Preferred	58,	59	59⅛		58
Do. Deferred	13½,	14½	14⅛		13 13-16
Brazilian Submarine	10⅞,	11⅛	11⅛		10⅞
Cuba	11⅜,	12½	—		—
Do. Preference	18,	19	—		—
Direct Spanish	2⅜,	3½	—		—
Do. Preference	7⅛,	8½	—		—
Direct United States Cable	8⅜,	9	8⅜		—
Eastern Telegraph	10⅝,	11	11⅛		10 7-16
Do. 6 per Cent. Preference	14,	14½	14⅝		—
Do. 5 per Cent. Debentures, 1899	106,	109	—		—
Eastern Extension	11⅛,	11⅜	11 15-16		11⅛
German Union	10⅛,	11	—		—
Globe Telegraph and Trust	5⅜,	5⅝	5 9-16		5⅜
Do. Preference	13⅛,	13⅜	13 5-16		13⅛
Great Northern	13⅛,	14	14		13⅜
Indo-European	36,	38	37½		37
Reuter's	7⅛,	8	—		—
Submarine	170,	180	177		—
West India and Panama	⅝,	¾	—		—
Do. 1st Preference	9,	9½	9 3-16		—
Western Brazilian	7⅛,	8	7⅛		—
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—
Do. 6 per Cent. Sterling Bonds	101,	104	—		—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	—		—
Oriental	5-16	7-16	—		—
United Telephone	12,	12½	12½		12½
United River Plate	4⅜,	5⅛	—		—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	1¼,	2	1 11-16		1 9-16
Do. (fully paid)	3,	4	—		—
Swan	1⅛,	1⅜	1 13-16		1 11-16
Maxim Weston	3-16,	5-16	¼		—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37½		—
India Rubber, Gutta Percha, and Telegraph Works	21½,	23½	22½		22

PRIZE MEDAL, PARIS ELECTRICAL EXHIBITION, 1881

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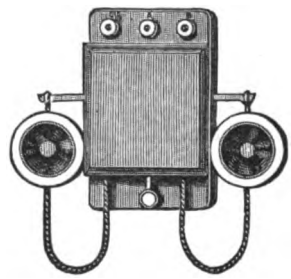

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NOTES.

CABLE REPAIRED.—The cable between Trinidad and Demerara, interrupted in the early part of this month, is now restored.

THE LIVERPOOL EXHIBITION.—The people of Liverpool are so dissatisfied with what they consider the emptiness of the Exhibition that they have christened it "The Spaceries."

A LONG CIRCUIT.—It is said that the longest regular land circuit in the world belongs to the Western Union Company, and runs from New York to Galveston, Texas, a distance of about 2,000 miles.

CITY AND GUILDS OF LONDON INSTITUTE.—We notice that Prof. Ayrton is to give a course of lectures on Electrical Technology at the Central Institution. These lectures will be given on Mondays and Thursdays, from 10 to 12, and commence on 6th October.

SHORTHAND.—In his address to the International Shorthand Congress, the Earl of Rosebery referred to the pressure of the times upon every class of civilised humanity, and stated that the telegraph, the telephone, and the postal card, in addition to shorthand, are nothing but the signals of distress of an overstrained civilisation.

IRELAND.—Besides ripping up the railroad to stop the passage of a train conveying the constabulary to a disturbed district last Tuesday, the insurgents broke down the telegraph wires. We call the offenders insurgents because these are operations of a kind which usually denote the beginning of warfare, whether civil or international.

IN THE FUTURE.—The *Financial News* says an electric car company will shortly be launched with the object of introducing electricity as a motive power on street cars and tramways. The experiments so far made are reported to have met with a fair measure of success, and if the investing public respond there is to be a new sort of electric boom.

TRAVELLING POST OFFICES.—From the Postmaster-General's Annual Report we learn that electric bells in the Railway Travelling Post Offices for the purpose of indicating when the mail bag exchanging apparatus is in working position have been introduced with great advantage, and that the system will shortly be extended to all the travelling post offices.

TELEPHONY FROM BERLIN TO HAMBURG.—The German Administration of Telegraphs, finding that the telephonic line between Berlin and Hamburg suffers from too much traffic, has reduced the duration of each conversation from five to three minutes, the price remaining the same. This measure has called forth some very lively remarks from the public who were accustomed to use this telephonic communication.

CHAMBERS OF COMMERCE.—At the meeting of the association just concluded, Mr. Dunlop, on behalf of the executive council, moved, and Mr. Murray, of London, seconded, that in any renewal of the concessions to the Submarine Telegraph Company it is desirable that the charges should be revised, and that representations be made to Her Majesty's Government to that effect. This motion was unanimously carried without discussion.

TELEPHONY AT SOUTHAMPTON.—The telephone company in this town have now 70 subscribers on their exchange service, a large number considering the short time the service has been established, and a convincing proof of the value of the system to men of business. The company are about to open an exchange service at Winchester, in connection with the Southampton district, of which Mr. P. Fitzsimons is the superintendent.

CHINA.—American advices state that the Mitkiewicz-Barker Chinese banking, railway and telephone concession has been ratified by the Chinese Minister at Washington. It is understood that $25,000,000 is the amount of capital to be invested, and report has it that Mr. Wharton Barker and some of his associates will go immediately to China to organise a national bank and lay out plans for the first railroad, which will probably be a strategical one for the transport of troops.

THE INDIA TELEGRAPH SERVICE.—A Reuter's telegram, dated Simla, September 26th, states:—"A dispatch has been received from the Secretary of State for India in reference to the block in promotion in the Telegraph Department. It directs that extra pensions are to be offered to induce officers to retire earlier than is allowed by the present regulations, and rearranges the graded list of officers with a view to give immediate relief. The dispatch states that no further concessions will be granted."

ELECTRIC LIGHT ON RUSSIAN RAILWAYS.—The Russian Minister of Ways of Communication has, says a contemporary, appointed a special commission to select the best system of electric lighting for railway carriages. This is the result of a decision recently arrived at to render the adoption of the electric light compulsory upon the principal railway companies for all passenger trains. The experiments will be conducted on the Nicolaieff Railway, and are not expected to last more than a month.

TELEPHONE MONOPOLY.—Do the people who write to the political papers ofttimes know what they are writing about? Those who declaim against telephonic monopoly in a given district will perhaps enlighten us as to the effect of two or three companies working in the district. We can see how bad such a competitive system would be, and our difficulty is to find out how it would benefit anyone.

LODESTONE.—Although almost every schoolboy knows Pliny's account of the discovery of glass, we do not remember to have seen in any electrical paper or treatise any mention of his reference to the lodestone in the history of this discovery. Yet Pliny, after describing the accidental discovery by the merchants, goes on to say that afterwards (as man's wit is very inventive) men were not content to mix nitre with the sand, but began to put the lodestone among the sand, thinking it would draw the liquid glass unto it, just as it drew iron.

BIRTHPLACE OF MORSE.—The house in which Prof. Morse the inventor of telegraphy, was born is still standing in Charlestown, Mass. It is on the corner of Main-street and Hathon-square, and is occupied by two families. On the street floor are two stores, one occupied as a grocery and the other as a shoe store. This house was one of the two that remained unharmed when Charlestown was destroyed by fire by the British in 1775. Morse was an artist of some merit, and on the walls of several of the rooms are to be seen sketches in oil from his brush.

THE VAN RYSSELBERGHE SYSTEM.—According to the proceedings of the Belgian Society of Electricians, the Van Ryssel-berghe system is applied to over 9,000 miles of line, of which nearly 4,500 miles are in Belgium, about 2,500 miles in France, about 600 miles in Germany, and the rest in Austria, Bavaria, Denmark, Spain, Holland, Switzerland, and Wurtem-

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burg. The system is in process, or is projected, some 3,700 miles in addition to the above, some of these extensions being in Turkey, Russia, Roumania, Portugal, and Italy. It will be recollected that this system permits of utilising the same wires for telegraphic and telephonic communication.

THE ELECTRIC LIGHT AND MOBILISATION.—It is interesting to learn that in the recent French mobilisation experiment the electric light industry was called upon to furnish its contingent. The work was carried out by MM. Sautter, Lemonnier and Co., who had to supply, at very short notice, the necessary materials to light the principal points of embarking and disembarking the cavalry—two at Toulouse and one at Carcassonne. At each station there was a dynamo giving 16 amperes current at 600 volts feeding a new arc lamp of 150 carcels. The dynamo was mounted upon the same truck as a portable engine, which was used to drive it, so that the whole of the apparatus could be easily removed.

MEXICO.—When we come to recognise that Mexico possesses more than 20,000 miles of telegraphic lines, besides the telephonic, it will be seen that a large amount of material is required for the filling up of the lines and offices. In providing such materials England seems to have a very small share, the greater quantity being obtained from the United States. The apparatus used is simple and duplex Morse. The line wire is of galvanised iron of 4mm. diameter. The insulators are those of the Chicago Insulating Company. The poles are of Eucalyptus wood, and seem to be about the only part of the apparatus provided by Mexico. Similarly with the telephonic apparatus, almost the whole of which has been provided from America.

BOOKS RECEIVED.—The fourth edition of *A Handbook of Electrical Testing*, by H. R. Kempe, is published by Messrs. Spon. Our opinion of this book has been often given. It is one of those few works that cannot be praised too highly. By far—in fact, it cannot be said to have a competitor—the best book on the subject of testing, it has been carefully revised and added to till it is almost impossible to conceive of further improvement. No electrician worthy the name can do without this work.—We have received also a copy of the new edition of Dr. Gore's *Theory and Practice of Electro-Deposition*. This work was, we believe, originally written for the "Circle of the Sciences," and according to the preface the necessary alterations and additions have been made in this edition to bring it up to date.

WESTERN COUNTIES TELEPHONE COMPANY.—The directors have resolved to allow the subscribers to their exchange systems and the public in Bristol, Bath, Gloucester, Newport, Cardiff, Pontypridd, Swansea, Llanelly, Landore, Morrison, Neath, and Briton Ferry to communicate with each other upon payment of certain small amounts varying from 6d. to 1s., and in order to convenience the subscribers they have decided to allow them to speak direct from their own offices, the account to be rendered monthly. Of course it is almost impossible to say how such an experiment as this will answer, but, as we have often argued, the success of experiments of this character will show how rapidly the telephone will compete with the telegraph. The advantages altogether are in favour of the telephone, inasmuch as not twenty words but a tolerably long sentence and a reply can in a very short period be transmitted and received.

LIGHTNING CONDUCTORS.—The *Electrotechnischer Anzeiger* describes a method patented by Messrs. Hoyer and Glahn (of Schönebeck, on the Elbe), who use an insulated copper wire introduced into the conducting apparatus and wound round an iron core. Over the core is suspended a magnetised steel plate. The latter communicates with a registering appliance, by which its movements are recorded. When a current of electricity passes through the conductor the iron core becomes magnetised and attracts the corresponding pole of the plate. After the cessation of the magnetic action the small plate will remain in its position. From the position of the indicator it is possible to determine whether lightning has passed through the conductor. In order to restore the apparatus to its original condition the indicator is turned back, the plate liberated and again suspended. It is stated that several hundreds of these appliances are already in use.

THE FIRST LIGHTNING CONDUCTOR.—If we are to believe an Austrian paper, says *La Lumière Electrique*, the first lightning conductor was not constructed by Franklin, but by a monk of Seuftenberg, in Bohemia, named Prohop Diwisch, who installed an apparatus the 15th of June, 1754, in the garden of the curate of Prenditz (Moravia). The apparatus was composed of a pole surmounted by an iron rod supporting twelve curved up branches, and terminating in as many metallic boxes, filled with iron ore and closed by a boxwood cover, traversed by 27 sharp iron points, which plunged at their base in the ore. All the system was united to the earth by a large chain. The enemies of Diwisch, jealous of his success at the court of Vienna, excited the peasants of the locality against him, and under the pretext that his lightning rod was the cause of the great drought, they made him take down the erection which he had utilised for six years.

OVERHEAD TELEPHONE WIRES AT DORCHESTER.—A correspondence has, we understand, been going on for some weeks past between the Town Council of Dorchester and the Secretary of the Western Counties and South Wales Telephone Company, who have erected a telephone wire across the Cornhill of that town, and declined to remove it, notwithstanding the protests and threats of the local council. The contention of the latter appears to be that they possess rights not only over the streets and buildings but over anything that may be carried across and above them. On the other hand, the company very naturally rely upon the ruling in the well-known Wandsworth case, and are averse even to admit the right of the council to require their sanction for any extension of the telephone company's business by overhead wires across the thoroughfares. Legal proceedings are threatened by the Town Council, the company meanwhile expressing their intention of erecting fresh wires wherever their business requires them.

PERSONAL.—A large number of telegraphists and others assembled on Friday last at the Nag's Head, Cloth Market, Newcastle, to bid farewell to two of their colleagues, Mr. R. W. Weightman and Mr. J. Younghusband, who are leaving to accept appointments under Government at Pietermaritzburg. Mr. M'Keone, in a short speech, presented each of these gentlemen, on behalf of the clerks in the Newcastle telegraph offices, with a large portmanteau, Mr. Weightman suitably responding. A letter was read from Mr. Younghusband regretting that, owing to his being desirous to spend the few remaining days in this country at his home in Keswick, he was unable to be present, but thanking his friends for the gift they had so kindly made him. Several other gentlemen spoke in the highest terms of Messrs. Weightman and Younghusband, after which songs were efficiently rendered by Messrs. H. Dowey, M. Brown, A. S. Lisle, F. W. Holmes, N. F. Clutterbuck, H. Kemp, Liddell, Taylor, and Weightman.

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ELECTRIC LIGHTING TARIFF IN MILAN.—At Milan there are now two distinct tariffs in operation, one based partially on a fixed annual charge, and the other upon the actual consumption. In the first case the rates are as follows :—

For 1	ampere	45	lires per annum	+5·5	centimes per hour of supply.			
,, 0·75	,,	35	,,	,,	+4·0	,,	,,	,,
,, 0·5	,,	22·5	,,	,,	+2·66	,,	,,	,,

The second tariff, in centimes, is as follows :—

	Below 41 hrs.	41 to 80 hrs.	81 to 100 hrs.	101 to 125 hrs.	126 to 150 hrs.	Above 150 hrs.
For 1 ampere	12	11	10	9	8	7·5
,, 0·75 ,,	9	8·25	7·5	6·75	6	3·6
,, 0·5 ,,	6	5·5	5	4·5	4	3·75

The meters are rented on the following terms :—

6 lires per annum.....for 50 lamps.
9 ,, ,, ... ,, 50 to 100 lamps.
12 ,, ,, ...above 100 lamps.

The company replaces the lamps burnt out at their own expense. Many of the above prices have no exact equivalent in English money, but are fractions of a penny.

ANOTHER ELECTRIC BOAT.—By the command of the Minister of Marine a series of experiments has been carried out at Havre with a new electric boat, designed for use in the French Navy. The boat under experiment was constructed by the Forges et Chantiers de la Méditerranée. The electric motor was from the design of M. Krebs, developed with a velocity of 850 revolutions, about 12 horse-power, driving a screw of 0·55 millimetre in diameter, about 280 revolutions per minute. The electric current is furnished to the motor by a battery of 132 accumulators upon the system of MM. Commelin and Desmazures, presenting, it is said, some decided advantages ; but of this it is impossible to speak unless we had a complete knowledge of the invention. The weight of the accumulators was about two tons. They furnish from eighty-seven to eighty-nine amperes, with a difference of potential from 100 to 104 volts. The constructor of the boat guaranteed a velocity of six knots for three hours, with ten horse-power during the experiment. The launch gave 6½ knots during five hours, developing twelve horse power.

CURIOUS EFFECTS OF LIGHTNING.—Our American contemporary *The Scientific American* reports that "The steamship 'Anchoria' of the Anchor line, which lately arrived in New York, met a tornado 180 miles from Sandy Hook. The wind came on from the north-east, and in a short time there was a tremenduous sea running. The rain came down in such floods that the crew were scarcely able to stand upon deck. The lightning poured in streams of a minute's duration from the clouds to the water, while globes of blue flame played up and down the rigging and danced along the yards, and leaped from the masts incessantly, terrifying passengers and seamen alike. For about two hours the wind blew at eighty miles an hour. Neither lookout nor pilot could see beyond the ship's rail, because of the solid sheets of rain and flying clouds of spray in which the ship seemed to be walled up as by a fog. The engines were run dead slow, and the ship lay to, head to the gale. At the end of two hours the gale broke, and pleasant weather soon followed. No damage was done by either wind or electricity. The steamship 'Glenartney,' from Shanghai, was in the same storm, and had well-defined tufts of electric fire on each masthead."

TELEPHONE EXTENSIONS IN SOUTH YORKSHIRE.—The Sheffield Telephone Exchange Company are busily engaged in making important extensions and developments of their system. Sheffield and Rotherham have been connected by telephone for many years, and subscribers in Rotherham have been in direct communication with the Sheffield Exchange by separate wires. The majority of the original Rotherham subscribers prefer to continue these direct connections, but a demand has arisen for a cheap local service which will at the same time provide communication with the Sheffield subscribers, and a central office has now been opened in Rotherham. New subscribers are being quickly attached, and the communication with Sheffield is provided by means of trunk wires. The wires are also being energetically pushed forward to Barnsley, and they will connect on their way the towns of Swinton, Wath, Kilnhurst, Mexbro', and Wombwell, thus uniting the large and important coalfields of South Yorkshire with the leading towns of Sheffield, Rotherham, and Barnsley. The local authorities over the entire route have cheerfully granted facilities for the erection of poles and wires, and have been prompt to recognise the commercial importance of the facilities that will shortly be at their disposal.

AMERICAN EXAMPLE.—Undoubtedly the meetings of the Electric Light Convention in America fulfil an object which it seems to us we in England should strive after. We have nothing of a similar character connected with electrical engineering, and certainly an attempt should be made to bring practical men together occasionally to talk over the practice of their profession. The scientific value of the papers read by our friends on the other side may sometimes be represented by a negative quantity, but the utility of the papers and the meeting is that, from beginning to end, the aim is to further "business" by discussing practical questions ; and when practical men will discuss their successes and their failures, good must assuredly ensue. What do our English practical men say ? Shall we take the work in hand, initiate a working committee, call a meeting and test the scheme, or let it drop ? How would the following names do for an executive committee :—Mr. Crompton, Mr. Parker, Mr. Garcke, Major Flood-Page, Mr. Sellon, Mr. Wharton, Mr. Statter, Mr. Fricker, Mr. Fletcher, Mr. Bennett, Mr. Walker, Mr. Kay-Gray, Mr. A. Siemens ? Mr. Fricker would no doubt act as secretary. Other names might be suggested, but these, we think, are fairly representative. We suggest that all those favourable to the idea should signify the same in the usual manner, viz., by writing and saying so.

A STRATAGEM.—According to the *Electrical Review* of New York, when the electric telegraph was first introduced into Chili a stratagem was resorted to in order to guard the posts and wires against damage on the part of the Araucanian Indians and maintain the connection between the strongholds on the frontier. There were at the time between forty and fifty captive Indians in the Chilian camp. General Pinto called them together, and, pointing to the telegraph wires, he said—"Do you see those wires ?" "Yes, General." "Very good ; I want you to remember not to go near nor touch them, for if you do your hands will be held, and you will be unable to get away." The Indians smiled incredulously. Then the General made them each in succession take hold of the wires at both ends of an electric battery in full operation. After which he exclaimed, "I command you to let go the wire !" "I can't; my hands are benumbed," said the Indian. The battery was then stopped, and the man released. Not long afterwards the General restored them to liberty, giving them strict injunctions to keep the secret, and not to betray it to their countrymen on any account. This had the desired effect, for, as might be expected, the experiment was related "in the strictest confidence" to every man of the tribe, and the telegraph has ever since remained unmolested.

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EARLY EXPERIMENTS.—Berzelius relates that Hansteen and Maschmann placed a solution of silver in a syphon-shaped tube that the silver might be reduced by metallic mercury, and they always found that when the two legs of the tube stood in the plane of the magnetic meridian, the silver in the northern leg shot out into more numerous and better formed crystals than in the southern leg, where, in fact, the reduced silver immediately mingled with the mercury. Upon placing the legs of the tube east and west the process of reduction went on much more slowly, and the reduced metal stood at an equal height in both legs. Murray made an experiment of the same sort, in which he placed iron wire in a weak solution of silver. So long as the iron wire had no magnetic polarity no silver was reduced, but as soon as a magnet was placed near it the reduction commenced. He also found the reduction most considerable at the north pole of the wire, which is in accord with the experiments of Hansteen and Maschmann. Lüdicke placed concentrated saline solutions in a glass vessel over the two poles of an electro-magnet. He employed acetate of lead, muriate of ammonia, or photo-sulphate of iron. When crystallisation had taken place, it appeared that there was a clear round space left vacant between the two poles where the magnetic force was strongest, though the rest of the bottom of the vessel was uniformly covered with crystals.

ELECTRICAL EXHIBITION AT NEW YORK.—Preparations, says the *Electrical World*, for the Electrical Exhibition of the New York Electrical Society are now going on on all sides, and before the month is out a very creditable display will be laid before the public of New York, where nothing of the kind has ever been attempted before. This year, the semi-centennial of the completion of Morse's first telegraph instrument, is well chosen for the exhibit, and the timeliness as well as the enterprise of the society has been very generally appreciated. At the present time over 18,000 square feet of floor space has been allotted, and this will be covered by exhibits in every branch of electrical industry, contributed by over twenty-five of the leading electrical companies and by a great number of other concerns well known in their respective lines. As already announced by the society, there will also be a loan collection of relics and historical apparatus. Altogether the exhibition promises to be very interesting, and to do much to further electrical science and industry. The society has had no other object than the general good in this effort, which has been in contemplation nearly two years, and it should receive every encouragement in its work. We may add to this that Prof. G. Forbes, F.R.S., is, we believe, on his way to America with a view to exhibit his beautiful meter, first described in England at the late meeting of the British Association at Manchester.

BOARD OF TRADE LICENSES.—A special meeting of the Liverpool Council was held on Wednesday to consider, and, if thought expedient, to approve of the mayor, aldermen, and citizens of the city of Liverpool, acting by the council as the local authority under the Electric Lighting Act, 1882, consenting to the Liverpool Electric Supply Company (Limited) making an application to the Board of Trade for a license to supply electricity for public and private purposes within certain parts of the city, subject to such conditions as the council may prescribe; and also to consider, and, if thought expedient, to approve of the draft license, and to prescribe the conditions contained therein as the conditions upon which the consent of the council is given to the application for a license by the company. The council was also asked:—To consider, and, if thought expedient, to approve of the intention to make application, and of such application to the Board of Trade by the mayor, aldermen, and citizens of the city of Liverpool, acting by the council as the local authority under the Tramways Act, 1870, for a provisional order to enable the Corporation to authorise the use of steam or other mechanical power on the tramways constructed under the Liverpool Tramways Act, 1868, and the Liverpool Tramways Act, 1871; also to consider, and, if thought expedient, to approve of a memorial by the council to the Board of Trade for a provisional order to enable the Corporation to authorise the use of steam or other mechanical power on the tramways constructed under the Liverpool Tramways Act, 1868, and the Liverpool Tramways Act, 1871.

ELECTRIC LIGHTING FOR THE CITY OF DUBLIN.—The committee appointed last May by the Corporation of Dublin to inquire into the possibility of using the water-power at Island Bridge for the purpose of lighting the city by electricity has just issued its report. It is chiefly taken up with reports from experts to whom the committee referred the several points involved in the investigation. Mr. Spencer Harty, the city engineer, states that the condition of the mill race at Island Bridge is very neglected, and would require to be cleared; but that there is even now an average mean velocity of 72·5ft. per minute, and a fall of 11·57ft. and 6·32ft. at low and high water respectively, the effective power being 52 horse-power and 27 horse-power. By altering one of the sluices on a later occasion an effective power of 98 horse-power and 50 horse-power at low and high water was obtainable. On the 16th August Mr. E. Manville, electrical engineer of the United Electrical Engineering Company, Lambeth, London, reported upon the electrical part of the scheme. Relying upon a constant water-power of never less than 50 horse-power it was sufficient to produce current for 45 lamps, each of 1,000 candle-power. He estimates that the plant required will cost £4,134, which includes nine and a-half miles of lead covered main for two double circuits; and the annual maintenance at £1,175. If the mains are laid underground in bitumen cases the extra cost will be £460, and maintenance increased by £50 per annum. After consultation with the law agent in reference to the terms of the Electric Lighting Act, the committee recommend that the scheme submitted by Mr. Manville be adopted.

EDISON'S NEW LABORATORY.—Menlo Park has obtained world-wide fame from its being the residence of Edison during his labours on electric light matters. Now Llewellyn Park at Orange, N.J., will probably form one of the centres of electrical development. Here Edison is having built a laboratory the equivalent of which will hardly be found on this planet. The main building is 250ft. long, 50ft. wide, and three stories high. The lower story may be termed the machine shop. The second story will provide a grinding and polishing department, photographic rooms, and drawing offices. The tools in the machine shop are to be driven by a 40 horse-power engine. The energy required upon the second floor will be obtained electrically. The upper story is to be devoted to more delicate apparatus, principally electrical. In an annexe to the main building will be three Babcock boilers of 75 horse-power each. There will be two of Armington and Sims' high speed engines, and four dynamos driven by those engines. In addition to the main building and its annexes, there are four other buildings each 100ft. long, 25ft. wide, and 16ft. high. One of these buildings is to be devoted to galvanometrical work, and in it the use of iron has been carefully avoided, the nails being of

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copper and brass, the tubes lead and copper, and the hinges, locks, window fasteners, &c., of non-magnetic material. In this building there will be seven piers of solid stone, entirely detached from the walls and the building, each being provided with a slate top having a covering of vulcanized hard rubber an inch thick. There will also be two large piers on a level with the floor 15ft. long and 8ft. wide. The second smaller building is to be a complete chemical laboratory. The third building will form partly a store room and partly a carpenters' shop. The last of these isolated buildings will be devoted to metallurgy.

TELEGRAPHIC COMMUNICATION WITH PARIS.—The French *Journal des Chambres de Commerce* has published some statistics relating to the French telegraph system, from which it appears that Paris has the following telegraphic communication with the rest of Europe :—Twelve lines to London, besides two from Marseilles to London having connections with Paris ; ten lines to Germany, of which four are with Berlin, two with Frankfort, and one each with Hamburg, Strasbourg, Cologne, and Mulhouse. Metz has no telegraphic communication with Paris. There are three lines with Austria, viz., two to Vienna and one to Bregenz. With other countries Paris has the following communications :—Belgium four, viz., two to Brussels and two to Antwerp ; Denmark one, viz., the submarine cable, Frédéricia-Calais ; Spain one, viz., to Madrid ; Holland two, both to Amsterdam ; Italy six, viz., two to Rome and one each to Florence, Turin, Genoa, and Milan ; Switzerland four, viz., two to Geneva, one to Basle, and one to Berne. As regards telegraphic communication with the provincial towns of France, Paris has six lines to Marseilles, four lines each to Bordeaux and Lyons, three each to Lille, Havre, Brest, and Toulouse, and two each to Amiens, Montpellier, and Nantes. All the other prefectures have one direct line to Paris, except Tulle, Quimper, Mont-de-Marsan, Foix, Carcassonne, Privas, Gap, Digne, Mende and Ajaccio, and these, it is said, are all to be placed in direct communication with the capital before long. The *Bulletin International de l'Electricité* says that the Conseil Général du Rhône has voted the establishment of telegraph lines placing Lyons in communication with Marseilles, St. Etienne, and Paris. The same paper states that a bronze line has been placed between Frankfort and Brussels. This line, which is for the present appropriated for the telegraphs, is destined eventually for the telephone service which is to be shortly established between Verviers and Aix-la-Chapelle, and later on between the Bourses of Frankfort and Brussels.

ELECTRIC LOCOMOTION.—On Saturday last a small number of gentlemen representing America and the Australian Colonies accepted the invitation of Lord Bury, the chairman of the Electric Car Company, to inspect the experimental electrical car running between Shoreham and West Brighton. Starting from Shoreham the visitors were run in the electrically-propelled car to Southwick, says the *Daily Telegraph*, at the rate of about twelve miles an hour ; then, as a further illustration of the principle, a heavily-weighted traction car, similarly propelled, was run towards Shoreham at a speed of from fifteen to twenty miles an hour ; and finally there was a smart trip to West Brighton. The car carries eighty cells stowed beneath the seats, and, as with the motor and the gearing beneath, all the apparatus is out of sight. Briefly, it may be said that starting and stopping are effected as rapidly as could be done with any conceivable species of traction. On these points the visitors on Saturday expressed themselves completely satisfied ; but the inspection was made with the eminently practical view of discovering not only the efficiency of the apparatus, but its comparative cost, and upon these points Lord Bury himself technically entered into careful explanations, stating what he considered were the conditions of the problem. At the present time horses and steam on tramways cost 6d. per car-mile. This, his Lordship said, they had taken as their basis, and they were actually running at 4d. per mile. The engineers stated the cost at even less. In order to be on the safe side, he would not pledge himself to 4d., but he would assert that they could run at less than 6d., and that every improvement in motor or accumulator would be so much to the good. The Immisch motor, to which much of their success was due, was within 3 per cent. of theoretic perfection, and therefore they could not expect much advance upon that ; on the other hand, the accumulators would admit of amendment in some particulars. He claimed, as a net result, that working on a bad line, with a gradient amounting to one in twenty, they had yet come considerably below the cost of horse or steam power.

TECHNICAL EDUCATION.—The sixtieth annual meeting of the German Natural Philosophers and Doctors of Medicine—the equivalent to our British Association for the Advancement of Science—took place last week at Wiesbaden, when Prof. Dr. Preyer, of Jena, read a paper entitled "Natural Philosophy and School," which was cordially received and enthusiastically cheered at its conclusion. The Professor condemned entirely the present German methods of teaching in the higher schools, as well as much of what is taught. He says there must be less sitting on benches and being crammed with a lot of subjects that are of little use except for a certain few ; that nature and practical objects must be more studied, there must be more activity out of school ; that for a maximum of time spent a minimum of value is received ; that the scholars about to matriculate for the University are devoid of practical sense, have no confidence in their judgment, have acquired no manual accomplishments ; and says a great deal more besides. This is by no means the first time all this has been brought before the public. Last winter a professor of one of the first technical colleges gave three lectures on the same subject, and put it even more forcibly that education should be more practical and less theoretical. Again, a week or two ago a leading industrial paper was praising the introduction of examinations, such as some college in England had lately published, as just what Germany had been striving to obtain for years past, and much regretting that they were behind us in this particular. When this is all put together, it leads to the idea that, as Germany is becoming more and more an industrial country, it requires a more practical method of schooling for its members ; and who can say, as time flows on, whether in the end the teaching in Germany and the Continent generally will not descend to practical methods not dissimilar to our own, which have grown up as practical necessity demanded ? If so, which is very probable, does it not behove us to keep such technical education as we have at present, and to be cautious, instead of rushing in for new schemes as proposed by the late Bill, which may turn out in the end to become similar to what they are trying to get rid of on the Continent ? If our attention were turned to giving the lower and lower middle-classes a more thorough, better, and broader education, it would do more towards assisting us to compete with other nations than a new scheme of technical education, which, as far as engineers—and that is a wide field—goes, is scarcely required ; but if anything should be wanting, it could be easily accomplished without a cumbersome Act of Parliament. —*Engineer.*

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 340.)

In disc ring dynamos of the Gülcher and "Victoria" type the radial depth of the core is necessarily much smaller than in bi-polar machines, in order to permit of the introduction of the extra poles without any undue leakage of the lines of force from one to the other. It can be shown that in these as well as in machines of any other class that the greater the radial depth the smaller will the weight of the armature become, both in iron and copper. The armature is, however, but a fraction of the total mass, and it must be remembered that the section of the field-magnet cores will increase with that of the armature, and, after a certain point has been reached, in a quicker ratio than that in which their length will diminish. Without attempting here to deal analytically with this point we will fix the ratio quantities in accordance with those proportions which in the author's experience have been found most satisfactory in practice.

The list of quantities for a machine giving the same output as before will be as follows:—

$p = \cdot4$	$M = 20$
$q = \cdot4$	$\gamma = \cdot65$
$\beta = \cdot04$	$\mu = \cdot6$
$\rho = 1$	$P = 4$

With regard to γ, it must be remarked that since the core has now to be laminated in two directions, a far greater proportion of the total space is unoccupied by iron; the coefficient has thus to be diminished accordingly. μ is also necessarily smaller, since the armature winding is now divided into four parallel circuits instead of two, and is therefore of less section. This characteristic in multipolar machines renders them peculiarly fitting for all purposes where very heavy currents are required, when in bi-polar machines the copper must needs be so massive as to cause the generation of serious eddy currents within itself, to say nothing of the difficulties in winding.

From equation 4 we have

$$R = 3\cdot6 \times 2\cdot08 = 7\cdot49, \text{ say } R = 7\tfrac{1}{2}\text{in.}$$
$$N = 502$$
$$A = \cdot00566.$$

The depth of copper $\mu\beta R = \cdot18$in.; this divided into three layers gives the section as ·06in. × ·094in. wide, from which we find

$$\mu = \frac{\cdot094}{\cdot094 + \cdot05} = \cdot65.$$

This figure is about 9 per cent. higher than that assumed, but the error is on the right side; it is therefore scarcely worth while to make an alteration in the radius, for which a convenient working value has already been determined.

The number of parts in the commutator must be a multiple of 4, since there are 4 poles. There must also be two adjacent sections of winding to each segment of the commutator, because the coil has to be begun from the centre of the length of strip and wound in opposite directions on either side so as to finish with both ends outside. Further, there are to be three layers in each section of coils. The total number of coils must thus be a multiple of 24, and N is therefore adjusted to 504. This will give 84 parts in the commutator.

The total number of lines passing through the armature are—

$$Z = \frac{117 \times 10^6}{504 \times 1000} = 232$$

But since in machines of this build there are two parallel magnetic circuits in the external field as well as through the armature, it will simplify matters to deal with one of these circuits only throughout. The number of lines which will be considered is thus 116, and the path through which they have to pass is one half the section, and also one-half the length of that in a two-pole arrangement; the resistance R_A thus stands as before, and is

$$\frac{\pi\left(R - \frac{pR}{2}\right)}{pq\gamma R^2} = 3\cdot22,$$

which multiplied by the saturation coefficient 2·45 = 7·9. The air gap $\delta = \beta R + \cdot156 = \cdot456$in.; this figure we will convert into ·5in. A convenient angle for the pole shoe is $\frac{2\pi}{7}$, and remembering that one-half the surface of the shoe only is to be considered in the single circuit, we find the area to be

$$\frac{\pi}{7} R^2 (q + 2p - p^2) = 26\cdot3,$$

and the resistance R_a is $\frac{1440}{26\cdot3} = 54\cdot5$, which added to the armature resistance is 62·4; thus $p_1 = 116 \times 62\cdot4 = 7{,}250$. The numerator constant in the resistance ρ for this type of machine may be taken as 1,300; the value of ρ is thus $\frac{1300}{15} = 86\cdot5$, and the waste lines are $\zeta = \frac{7\cdot250}{86\cdot5} = 84$. One half of these lines only are supplied from the single circuit which we are considering, thus Z_2 must be taken as $116 + 42 = 158$. The section of the field cores must thus be $\frac{158}{18 \times \cdot8} = 11$ sq. in., for which a circular bar 3·75in. in diameter would be used.

The depth of winding on the exciting coils will be $\frac{3\cdot75}{4} = \cdot937$, say 1in.; giving the length of a mean convolution as 15in.

In multipolar machines it is usual to connect the series part of the winding on the several bobbins in parallel, or, at least, to make a multiple-series connection. The arrangement is often modified in similar machines under different circumstances. The average section of wire in the whole winding will not, however, be much affected by the arrangement of the series-winding, since the latter bears a considerably smaller proportion to the total winding than does the shunt, which is unaffected.

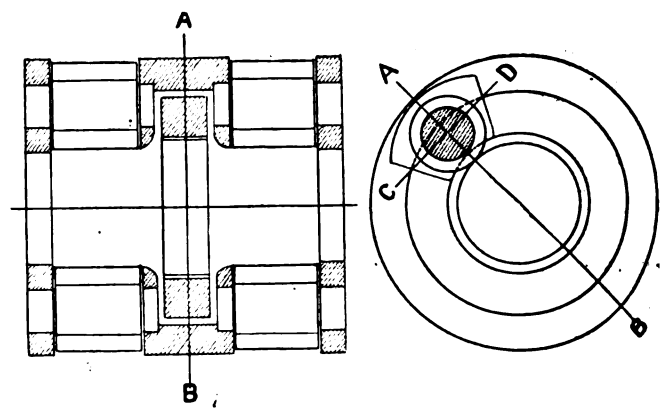

FIG. 16.

In making the rough calculation for the length of the cores we will suppose the average current to be 5 amperes only, instead of 7, in order to allow for the required lattitude in μ_1, which we will first assume as ·65. The number of watts dissipated per linear inch of core is $3\cdot75\pi = 11\cdot8$; we thus find the average value of A to be ·00289, the corresponding circular wire to which is ·0606in., giving

$$\mu_1 = \cdot885 \times \frac{\cdot0606}{\cdot0606 + \cdot02} = \cdot664$$

The number of turns per inch is $n = \frac{\mu_1^2 d}{A} = 152$, and allowing 2,000 ampere turns for the external circuit we have $\frac{7250 + 2000}{152 \times 5} = 12\cdot15$in. for the total winding, say 6¼in. outside measurement for each bobbin. In Fig. 16 the above dimensions are drawn out. It will be observed that the axis of the field-magnets is above the centre of the section of the armature ring; this is necessary in order to get sufficient strength at the junction of the magnet bar with the pole shoe. A good rule to adopt is to find the centre of the magnet bar on the chord C D, as shown in the figure. The mean radius of the frame in the

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present case is 7in. The depth of the frame is most suitably made slightly greater than the outside diameter of the exciting bobbin, which is here 5·75in.; the frame is therefore made 6in. deep. Since cast iron has a much lower specific magnetic conductivity than wrought iron, its section in the magnetic circuit must be proportionately increased. In practice it is found that ordinary samples of cast iron can most safely be considered as having but one half the conductivity of soft wrought iron; thus, since the lines divide into two branches on entering the frame, the section of the latter must be equal to that of the magnet bar, viz., 11in.* The thickness will be $\frac{11}{6} = 1{\cdot}83$, say 1⅞in. The total length of the external circuit, allowing for the thickness of the pole-shoes, is 26½in.; the resistance R_F is thus $\frac{2 \times 26{\cdot}5}{11} = 4{\cdot}83$, and $K_2 R_F = 4{\cdot}83 \times 2{\cdot}45 = 11{\cdot}83$, which gives $p_2 = 11{\cdot}83 \times 158 = 1{,}870$, and $P = 7{,}250 + 1{,}870 = 9{,}120$.

The weights will be as follows:—

Armature core	62 lbs.
Magnet cores	155 „
Frame sides.....	260 „
Pole-shoes, say	80 „
Armature winding	12 „
Field-magnet „	104 „

The total weights of the various materials being—

Wrought iron.....	217 lbs.
Cast „	340 „
Copper	116 „

The resistance of the armature is ·045 ohm, thus the loss in watts is 450.

The loss in the magnets will be 590 watts, whence the electrical efficiency is $\frac{10000}{10000 + 1010} = 91$ per cent. nearly.

An examination of these three designs will show that as electrical instruments there is very little to choose between them. The drum armature is the most efficient, but it is also the heaviest, whilst the multipolar ring machine is the lightest of all, but also the least efficient. Considered from an engineering point of view, the 4-pole arrangement certainly appears to be the best, chiefly on account of the superior accessibility of the armature coils and also for its splendid ventilating properties. In these respects the drum arrangement is as certainly the worst.

REINFORCING ELECTRICAL CONTACTS TO INCREASE THEIR RELIABILITY,†

WITH EXAMPLE OF APPLICATION TO REELING SILK FROM THE COCOON.

BY E. W. SERRELL, JUN., NEW YORK.

The object of the paper is to explain a method of securing a good electric contact under circumstances in which ordinary solid or mercury contacts will not work.

The method consists in the use of a sucking coil or small electro-magnet, placed near the contact and traversed by the whole or a part of the current when the circuit is closed. When the contacts touch, no matter how lightly or imperfectly, the magnet or coil is excited and acts on an armature in such manner as to cause the parts of the contact to be drawn more firmly together and to scrape over one another so as to be cleaned by a mechanical action produced by the current itself every time that contact is made. By this method all the difficulties commonly experienced in the use of electric contacts may be overcome. If the parts are made to touch even in the slightest degree a thoroughly good contact is instantly secured.

The method is applicable to signalling apparatus and many other purposes, and is already used with success by the inventor in automatic machinery for reeling silk from the cocoon. By its use contacts have worked reliably for very long periods under circumstances which would give rise to insuperable difficulties without it.

Its application to automatic machinery for reeling silk from the cocoon was explained. This machinery has created a new industry, all silk having hitherto been reeled by hand.

The use of electrical appliances for reeling silk is greatly facilitated by the employment of this device, and is leading to important results; and the inventor considers that, as by this means a perfectly reliable contact is easily obtained, the use of electricity for controlling textile and other machinery may be very greatly and advantageously extended, especially in all cases in which light contacts must be used.

* Care must be taken to secure the full magnetic conductivity at the junctions of wrought and cast iron.

† Abstract of a Paper read before the British Association Meeting at Manchester, September, 1887.

THE LATE MR. O. E. WOODHOUSE.

By the death of the senior partner of the firm of Woodhouse and Rawson, which it was our painful duty to briefly notify in our last week's issue, the electrical world has lost one of its most enterprising and practical engineers. The melancholy event, which took place on the 21st inst., at Brighton, whither the deceased gentleman had gone to recruit his exhausted energies, was not altogether unexpected, for he had been suffering for a period of two years from the strain of overwork, intensified no doubt by the protracted litigation in which his firm was involved with the Edison and Swan Company towards the end of 1885. At that time, feeling that his strength was giving way, Mr. Woodhouse, acting under the advice of his physician, left England for a short residence in Cannes, where he had the misfortune to contract a fever, from the effects of which he never wholly recovered, and to which in a great measure his premature demise must be ascribed.

Mr. Woodhouse was a native of London, where he was born on the 21st October, 1855. He received his elementary education at Marlborough College, from which he proceeded to King's College, London, where he acquired that knowledge of physical science which stood him in such good stead in his subsequent career as a practical electrician and engineer. From King's College he passed directly to the workshop of Messrs. Hunter and English, the well-known engineers of Bow, with whom he spent three years, principally in their fitting department. In August, 1877, he entered the service of the Great Eastern Railway Company under Mr. W. Adams, the locomotive superintendent, with whom he formed so close a friendship that when Mr. Adams accepted a similar position in the service of the London and South Western Railway Company Mr. Woodhouse elected to follow the fortunes of his chief, and transferred his services to the workshop of that company, where he remained until the beginning of 1881. In July of 1880, Mr. Woodhouse made a journey to America with Mr. J. C. Peache, assistant to the London and North Western Railway Company's locomotive department at Crewe, and spent six months in inspecting the principal engineering and general scientific works both in the United States and Canada, from which he learned many of those practical lessons in engineering which he turned to such good account on his return to England towards the close of that year. Shortly afterwards—in 1881—he entered into partnership with Mr. F. L. Rawson, under the title of Woodhouse and Rawson, and to his great energy and ability was due in a great measure the world-wide reputation which the firm have acquired as electrical engineers. Notwithstanding the many claims which his business had upon his time, the deceased still found leisure to cultivate some of the amenities of life, and, as is well known, was a keen votary of athletic sports. His funeral, which took place at Kensal Green Cemetery, on Monday last, was largely attended by his personal friends and the *employés* of the firm, a fitting tribute to the memory of one who as an associate and master had by his many sterling qualities earned the esteem of all who came in contact with him.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE POSTMASTER-GENERAL'S ANNUAL REPORT.

It may be due to natural curiosity in respect to one particular branch of the Post Office, but our impression after a careful examination of the POSTMASTER-GENERAL'S Annual Report just published is, that the familiar little Blue Book for the year ended 1886-7 is fuller than usual of details we did not want, and emptier than usual of information we had a right to expect. On its own merits we should have thought that the Post Office Telegraph was at least as important a branch of the Post Office as, say, Post Office Annuities and Life Insurance, or the issue of Licenses for Dogs, Armorial Bearings, and Hackney Carriages, by the same Department. But either this is not the view of the POSTMASTER-GENERAL, or else the head of each Branch is allowed just as much space as the importance of his business, in his own estimation, may seem to demand. If this latter be the correct explanation of the paucity of information relating to the telegraphs contained in the present Report, the persons responsible for it must be exceptionally modest, and will not be surprised that they are taken at their own measure. The way in which they are classified in the table of superior officers (page 25) might satisfy the humblest of mortals. Amongst the 42 superior officers in the metropolis just three are included who belong to the Telegraph Service. There is, for example, one male Engineer-in-Chief, who, if we mistake not, is the engineering head of the telegraph service of the whole United Kingdom. There is also one Female Medical Officer, whose functions, whatever else they may be, are certainly not telegraphic. But she is a "superior" officer of the Post Office, and, as such, apparently counts for just as much as an Engineer-in-Chief of British Telegraphs. On the same principle, we are told to an ounce the weight of correspondence carried for other than Post Office Departments; but we can learn nothing as to the present average length of telegrams, or the speed of their despatch and delivery now that they are so much more numerous than formerly. Nor are we in any way helped to a conjecture as to the financial prospect of the experiment which provokes these inquiries.

That the reduced tariff which came into operation on the 1st October, 1885, has been a great success so far as increase of traffic is concerned can hardly be gainsaid. Whether it has been equally satisfactory from the revenue point of view may be doubted from the little that is said about that aspect of the question in the Report. We hesitate to quote exact figures in this relation, for the tables, which seem to have been framed by different hands, show different results according as we include or exclude this or that item of Receipts or Expenditure. But roughly it may be gathered that while the business and the income go on increasing, so does the deficit. Between the Receipts for 1885-6 and 1886-7 there is a difference of, roughly, £100,000 in favour of the later year; and there is almost the same difference of expenditure in favour of the former. It is too early to make predictions, but it is obvious that if this course of things continues the annual deficit will in due time overtake the Receipts, unless, indeed, the Expenditure becomes stationary, which is unlikely, and the Receipts increase at their present rate, which is highly improbable. This is not a very cheering prospect, and perhaps it may account for the POSTMASTER-GENERAL'S brevity and reticence in regard to the Telegraph Service generally. No useful comparison between two whole years can be made, because the first half of 1885 was worked under the shilling rate; but during the closing halves of 1885-6 and 1886-7 respectively, both under the sixpenny rate, the increase of messages was at the rate of 14 per cent., the increase in payments being 13 per cent. The exact figures are 19,071,782 against 16,737,837, and £641,709 against £566,039. The interest on the original capital expended for the purchase of the Telegraphs, amounting to £326,417, constitutes a permanent charge equal to nearly one-fifth of their present income. A few years ago, in 1880-1, this charge was almost met by the net revenue, the deficit being only £984; but since then the deficit has rapidly increased, the balance between Receipts and Expenditure being less and less every year. In the face of this fact the tariff was reduced in 1885, with a then deficit of £36,350 in excess of the permanent charge, and to-day it amounts to £469,840, or £143,423 in excess. In other words, the Telegraph revenue would be the last-named amount to the bad, even if interest on the original outlay were wiped off.

For the purpose of ascertaining the effect of the reduced rate on the number of messages a comparison may be made between the two periods, April to September, in the years 1885 and 1886; and according to our calculation the increase in the latter half year was 8,362,226, or at the rate of, say, 16 millions for the whole year. This, on a total of about 40 millions, excluding foreign press and other messages not affected by the reduced tariff, is highly gratifying to the promoters of cheap telegraphy, and we may leave the figures for them to make the most of. If we could be at all sanguine that a comparison between two whole years of sixpenny telegrams will show a rapidly growing revenue and even a slow diminution of expenditure we might share their satisfaction. At present the condition of affairs appears to be that with an enormous development of traffic the necessary outlay in dealing with it is not less enormous, and that consequently we are enjoying cheap telegraphy at the expense of the taxpayer, which is precisely what we have all along foretold. No extensions of unusual magnitude are mentioned in the POSTMASTER-GENERAL'S Report, and we are led to infer that the additional expenditure is incurred chiefly by extra working expenses; and if that be the case there is every apparent

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likelihood of their increasing as the traffic goes on enlarging. A new line has been erected to North Wales, and a fresh cable laid from thence to Ireland, at a cost of £40,700. New telegraph offices have been opened also at 232 post offices. These facts show that the Post Office Telegraph Department is adequately meeting the demands which a popular tariff necessarily creates. But it cannot be supposed that these demands will diminish, or that the efforts to meet them will be allowed to slacken. Some allowance in the year reported upon must, of course, be made for the expenditure entailed in repairing and renewing wires broken down last winter by a snowstorm of almost unprecedented destructiveness; but to meet such contingencies in future the popular cry is for greater immunity, and this, of course, means increased outlay at no distant date. On the whole, although the public who are customers of the Telegraph may be congratulated on possessing the cheapest and most efficient service in the world, the country is not to be complimented on the precipitancy with which the cheapening was accomplished.

CORRESPONDENCE.

SPRINGS ON TELEGRAPH WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reporting the discussion on Mr. Preece's paper read at the British Association meeting, you say that I spoke of practical objections to Sir F. Bramwell's suggestion of the use of a spring at every telegraph post. The vague assertion that there are "practical objections" to an untried invention is very easily made, and usually leads to no loss of reputation when disproved in actual working. I said at the time that the suggestion was very ingenious, and would be satisfactory only for the size of spring required. The cost of the new fitting must, in any case, be considerable, and although even a small spring must do some good, it ought not to be introduced unless the good it does is commensurate with its cost. When the tension in a telegraph wire increases, the wire increases in length in consequence, and it is on this account that the increased dip of a telegraph wire in summer does not follow the formula usually given connecting temperature of the wire and dip, or rather, the summer temperature of a wire is usually much higher than it is assumed to be in the calculations of telegraph line men. We all know, then, that the actual extension of the wire due to stress introduces an important regulating effect.

By calculation it may be shown that if there is a tensile stress of $\frac{1}{4}$ of the breaking stress in a telegraph wire due to its own weight, then a total load of more than three times (and not merely twice, as it would be but for the extension of the wire) the original load is needed to produce twice the stress, or half the breaking stress. So great is this regulating effect that the compensation springs designed by me for use at the heads of posts in telpherage and other contrivances for the same purpose have proved to be unnecessary.

Let us assume that Sir Fred. Bramwell's spring is at least large enough to introduce as much of a regulating effect as the extension of the wire itself. I take it that this is the least amount of regulation for which it is worth while to introduce the new fitting. In an iron wire 300ft. long, if the stress changes from 12,500 to 8,333lb. per square inch, it shortens 0·52in. If the iron wire was No. 7½ we therefore want a steel spring whose highest working load is, say, 270lb., and which shortens by 0·52in. when the load becomes 180lb. That is, a steel spring is required at every post which will work up to a pull of 270lb., with an extension of 1·56in. Its proof load would be 540lb., with an extension of 3·12in., so that a resilience of $\frac{540 \times 3{\cdot}12}{12 \times 2}$, or 70 foot-pounds, is required.

The resilience or the energy which may be stored up in a spring before it takes a permanent set is, for a given material, simply proportional to the weight of the spring, and does not depend on the size of the coils or of the rod or wire of which the spring is made. I find that the steel spring required to introduce as much compensation as is already introduced by the elasticity of the wire itself would weigh about 4lb., taking 50,000lb. per square inch as the proof shear stress of the material of the spring. I have here assumed a breaking shear stress of 100,000lb., or nearly 50 tons per square inch in the material of the spring, and if this is regarded as too high, the weight of the necessary spring at the top of each telegraph post for each telegraph wire must be increased. The weight of the spring is nearly inversely as the square of the proof stress (or stress which would produce permanent set). If the proof stress is taken to be only half what I have chosen, the weight of each spring for each iron telegraph wire on each pole would be more than 16lb., and this would only introduce as much of a regulating effect as the elastic yielding of the wire itself already introduces. At the B.A. meeting I thought that some such weight of steel in the spring as 10lb. or 12lb. must be assumed, but I knew quite well that experiment on an actual line was the only method of settling the question. If steel springs can be manufactured which shall with perfect certainty take no set for shear stresses of 50 tons per square inch my "practical objection" to Sir Frederick Bramwell's suggestion disappears, as the weight of each spring would then only be slightly in excess of 11lb.—

Yours, &c.,

JOHN PERRY.

10, Penywern-road, S.W., Sept. 19, 1887.

FORMULÆ FOR SELF-REGULATING DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: That the formulæ usually given for the compounding of self-regulating dynamos are not sufficiently accurate for practical use was shown in two articles I wrote for *The Electrician* in 1885.* These formulæ are based on the assumption that the strength of magnetic field is throughout proportional to the exciting current for the whole range of the shunt and series excitement, a condition which, needless to say, does not obtain in practice. The magnets being partially saturated before the series coils begin to act, a greater number of series turns is required than the formulæ would lead us to suppose, the mean value of each ampere turn in adding to the E.M.F. being much less than the mean value of each ampere turn of shunt wire.

Although we do not expect the formulæ to give accurate results with such an assumption underlying them, still the partial saturation of the magnets by the shunt scarcely accounts for the discrepancy manifested, a discrepancy due, I believe, to the weakening of the field by the armature current and to the counter E.M.F. set up by self-induction. On this account the E.M.F. added by the series coils is altered when the factors making up a constant product of ampere turns and speed vary, even when in machines of similar size the magnets are saturated to the same degree by the shunt coil.

The proportion of excitement furnished by the series wires varies not only in machines by different makers but in different machines by the same makers according to the purpose for which they are designed, and depending largely on the relation of weight to output. In machines having a large number of turns on the armature and giving a large output for their weight the series winding may furnish one-half of the total excitement, whereas in machines with few turns on the armature, weighty but more efficient, the series wire may furnish but one-fifth of the total. If we imagine that the series wire gives at full load a field strength equal to one-tenth of that given by the shunt, then in the first machine, where half the excitement is furnished by the series, the mean value of each ampere-turn of the latter is ·10 that of each ampere-turn of the shunt; while in the case of the machine where one-fifth is supplied by the series the mean value is ·40. To put it in other words, the number of series turns given by the formulæ would require to be multiplied in the first instance by 10, and in the second instance by 2·5, the former number being the highest coefficient I have known.

In every size of Phœnix machine the ratio between the ampere turns furnished by the series wire and the ampere

* "Note on the Regulation of Dynamos, Vol. XV., pp. 59, 89

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turns on the armature is the same, whatever be the speed or E.M.F., the shunt coiling being such as to secure under these conditions proper regulation. A difference is made only in special cases where the characteristic is required to rise considerably, or where an alternative winding for charging accumulators is required.—Yours, &c., W. B. ESSON.

London, Sept. 26th, 1887.

ELECTRICAL DISTRIBUTION BY ALTERNATING CURRENTS AND TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your reviewer of my little pamphlet refers to my experiments with induction coils in 1883, and states that these experiments were made with series transformers. That is true so far as the experiments designed to prove the existence of the detrimental counter-electromotive force in the series system was concerned. The experiments were made and described to prove that induction coils, as patented and employed in series order of distribution by Jablochkoff, Gaulard-Gibbs, and others, could not succeed, for the simple reason that the consumers would all be dependent on each other, and that the opposing forces in the primary increase as work in the secondary decreases, a condition which was obviously diametrically opposite to that required for a successful series system.

I do not assert that the series system is an impossibility; what I asserted, and still assert, is that no series system yet patented can possibly distribute successfully.

The systems described in the specifications prior to 1883 are all series systems; they might partially succeed in a limited distribution system by using transformers with over saturated cores, but the number of lamps on each transformer would require to be small, and then connected in series, and it could be shown that the economy of such a system would be under 50 per cent.; and I maintain that that is the best that can be done with the Jablochkoff or any other early system, even with the aid of all the knowledge and experience now to be found on the subject.

And, considering the claims made by the owners of these early patents, any inventor who may have an improvement which might make a success of the series system, had better keep it to himself; if there is any money behind these owners they will adopt his improvements, and very likely call him an infringer of Jablochkoff's patent.

The experiments which proved to me the self-regulation in the parallel system were made with mains at 1,000 volts, so that I can hardly be said *to have overlooked the possibility of using high tension mains*, as stated by your reviewer.

My remark about the size of the wires is not so far from the mark, as very little over 2,000 volts can yet be used over any system. At the date of my writing 1,000 volts was a high pressure, and at that pressure I guess the size of the conductors for a distribution of, say, 100,000, 16 candle-power lamps would still truly be "prodigious," and that number of lamps is not large when talking of lighting towns and cities, as the promoters of electric lighting were then doing.

Referring to Messrs. Manville and Madgen's letter, I can only say that Jablochkoff's specification describes and claims the series system of distribution by induction coils. The patent is for a combination of old and well known apparatus combined together in a *particular method* for distribution of electric lights. The combination consists of an alternating or intermittent current generator with a metallic or conducting wire circuit and induction coils placed in series order, and these induction coils supply current to lamps (shown also in series order).

The combination failed entirely to effect the purpose—*it would not distribute;* and although it was afterwards taken up by at least half-a-dozen subsequent inventors during the ten years following the date of the invention, none of them succeeded with it. The *secondary circuits are not independent of each other electrically, and neither primary nor secondary circuit is self-regulating.*

Neither is the combination new. A patent granted to C. W. Harrison, Woolwich, in 1857, describes the same combination; here we have a primary circuit in connection with an induction coil, and the induced current operates the light.

Jablochkoff's second claim is for a system "substantially as herein described" a series system, which does not contain a single one of the elements which are *essential* in the now successful system.

The "intelligent workman" test would settle this point easily. Put Jablochkoff's patent specification into the hands of an electrical engineer of ordinary skill, could he from that specification ascertain anything at all which would lead him to lay down a distribution plant containing the elements absolutely necessary for the succesful operation of the lights? Does the specification direct him to employ *high pressure* in the mains, *constant pressure* in the mains, *induction coils* with their *primaries connected in parallel* to the mains, induction coils with a certain ratio of reduction, induction coils with a certain amount of impedance? I trow not. The directions are to connect the primaries in series. The engineer would therefore conclude that a constant current and variable E.M.F. in his primary was the proper thing. He would set up a constant current dynamo and place his coils in series, and if he followed the specification further he would put his lamps in series also, and then he would find the whole arrangement a failure.—Yours, &c.,

Glasgow, Sept. 26, 1887. RANKIN KENNEDY.

BATTERY WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will any of our electricians kindly give me a description of a battery that will light 10 12-volt lamps four hours a day for one week with one charge? I have some porous pots 9in. by 3in. which I should like to use.—Yours, &c.,

J. BARTON.

309, Regent-street, London, W., Sept. 28th, 1887.

ON THE SPECIFIC RESISTANCE OF COMMERCIAL IRON.*

BY W. H. PREECE, F.R.S.

So many improvements have been made in the quality of iron supplied for telegraphic purposes that I was anxious to determine with great accuracy the specific resistance of that which is now used.

For this purpose a length of Swedish charcoal iron, carefully prepared, and similar to that used for the best iron telegraph wire, was drawn for me by Messrs. Frederick Smith and Co., of Halifax. The results were as follows:—

Test of 75 feet of Swedish iron wire, weight 2259·86 grains; diameter ·040 inch, or 40 mils. One foot of pure copper wire, d millimetres in diameter, has, according to Dr. Matthiessen, a resistance of $\frac{10{\cdot}323}{d^2}$ ohms at 60deg. F. Resistance of 75 feet of pure copper wire, 40 mils. in diameter, $= \frac{10{\cdot}323}{40 \times 40} \times 75 = {\cdot}4839\omega$. Now, by very careful measurement, the resistance of the Swedish iron wire $= 2{\cdot}920\omega$ at 60deg. F.; therefore, the relative resistances of copper and iron wires are as

$$\cdot4839 : 2{\cdot}920$$

or as

$$1 : 6{\cdot}034.$$

From this it appears that the specific resistance of commercial iron such as is now used is 6·034 instead of 6·558, as usually given in text-books.

The specific resistance at 60deg. F., or the resistance in absolute C.-G.-S. units of a centimetre cube is as follows:—

Silver	1·609
Copper	1·642
Pure Iron.....	9·7535
Commercial Iron	9·907, instead of 10·769.

Pure iron at 0deg. C. is taken at 5·94 times that of pure cop-

* Paper read before the British Association Meeting at Manchester, September, 1887.

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per (Matthiessen, *Proc.* R. S. 1863, p. 472). If, therefore, we take Matthiessen's figure as the resistance of pure iron, the wire now supplied has a conductivity of 98·44 per cent. of pure iron.

The temperature coefficient was obtained on another length of the same wire.

TEMPERATURE COEFFICIENT. TESTS OF IRON WIRE.

Temperature Centigrade.	Resistance.		Remarks.
	Measured.	Calculated.	
Degrees.	Ohms.	Ohms.	
17	10·83	10·83	Length of wire, 293 feet.
20	11·03	10·99	Weight of wire, 8,807 grains.
25	11·23	11·25	Diameter of wire, 40 mils.
30	11·53	11·53	
37	11·93	11·92	
41	12·13	12·15	$Rt_1 = R_t (1·0043)^{t_1 - t}$.
48	12·53	12·57	
53	12·83	12·87	
59	13·23	13·25	
65	13·63	13·63	
73	14·13	14·16	
80	14·63	14·65	
86	15·03	15·08	
92	15·43	15 52	
95·5	15·73	15·78	
97·5	15·93	15·93	

The following figures will be found useful:—

1 foot grain of pure iron	1·097 ohm
1 metre-gramme of pure iron	0·7654 ohm
1 ohm-mile of pure iron	4368·94lbs.

Knowing the ohm-mile of any iron wire which is obtained by multiplying the weight in lbs. per mile by the resistance per mile we readily get the percentage of conductivity of pure iron of that wire.

DISCUSSION.

Sir WM. THOMSON: What is the difference between the percentage of ordinary iron and the purest iron? And again, is it a commercial difficulty to get iron of the very highest conductivity that iron gives, or is it relatively as easy as it is to get copper of the best conductivity?

Mr. PREECE: There is little difference in copper.

Sir WM. THOMSON: Well, the price of high conductivity iron and good mechanical qualities will be very large in comparison with that of iron having much less conductivity?

Mr. PREECE: The difficulty of getting this pure iron is very great, but it is an £.s.d. difficulty. The price of the best conductivity iron wire runs to something between £15 and £20 per ton—that is, taking the iron at 98 per cent.; but if you are satisfied with iron at 90 per cent. it makes a difference of £5 or £6 a ton, and hitherto we have used this pure iron in the Post Office service in order to secure high efficiency in working. That is now being secured by copper. Copper is going to oust iron out of the field, and I think the necessity of paying this high price for high conductivity iron has diminished very much.

Sir WILLIAM THOMSON: I see that in the table purest iron is quoted at 97½ and commercial iron 99, so that there is only 1½ per cent. difference; but the difference between commercial copper of different qualities, such as were used in cable-making work before the year 1858, was as much as from conductivity 30 to conductivity 100. A great deal of the wire that was put into submarine cables at that time was of only 35 conductivity, and a rough average of the different copper wires sent in for making submarine cables was about 70 instead of 100, and at the present time the non-conductivity copper will be found to be not more than a half, and sometimes less than a half, of conductivity copper.

Mr. PREECE: This is only a comparison between the best commercial iron and pure iron. The ordinary iron that is used is very much below this indeed, and there is quite as much difference between ordinary iron and this form of it now as there was between the coppers in the days you speak of.

Sir WM. THOMSON: Then some of the iron wire may have the conductivity required.

Mr. PREECE: There is plenty of iron wire which gives as much as 15 ohms per mile. This gave 12.

Prof. S. P. THOMPSON: Will Mr. Preece be good enough to tell us something about the chemical analysis of this iron? One knows that the electrical deposits on iron must be presumably purer than other deposits, and that such iron has many different properties in many respects than iron produced by ordinary processes.

Mr. PREECE: I gave that information in a paper which I read before the Institution of Civil Engineers in 1884 or 1885, and this paper is the outcome of that paper. It gave the analyses of various classes of iron wire, but it was wanting in the particular information that this paper supplies; but Prof. Thompson will find the information he wants there.

Sir R. BALL (the President): I should like to ask Mr. Preece what was the weight of the iron wire a mile long at an ohm resistance.

Mr. PREECE: 4,368lb.

Sir R. BALL: Two tons practically?

Mr. PREECE: Yes, very nearly.

Sir R. BALL: Iron wire a mile long and two tons weight has an ohm resistance.

Mr. PREECE: I might mention that, knowing the weight to the ohm-mile, you have the resistance per mile of any other weight. For instance, we have got a mile of wire of any given weight; divide 4,368 by 400, and you have the resistance per mile.

ON THE INFLUENCE OF A PLANE OF TRANSVERSE SECTION ON THE MAGNETIC PERMEABILITY OF AN IRON BAR.*

By Prof. J. A. EWING, F.R.S. (University College, Dundee), and Mr. WILLIAM LOW.

It has been remarked by Prof. J. J. Thomson and Mr. H. F. Newall, that when an iron bar is cut across, and the cut ends are brought into contact, the magnetic permeability is notably reduced.†

Our attention was drawn to the matter in experimenting by the "isthmus" method described in former papers, when we attempted to use, instead of a solid bobbin, a short cylinder for the narrow central neck, separated by transverse planes of section from the conical ends. We found that even when such a cylinder was placed in close contact with the ends of the cones the induction in it was much smaller than in the neck of a solid bobbin of corresponding size; and we were forced to ascribe this defect of permeability to the fact that the induction was being measured at a place only a little way from two planes of transverse section. To examine the influence of transverse section more fully, and to see how far that influence is modified when the pieces are pressed against one another, we made a separate series of experiments, in which the permeability of cut and uncut wrought iron bars was determined by a method similar to that used by Dr. J. Hopkinson.‡

The bar to be tested was let into a massive rectangular yoke of wrought iron, forming a double path for the return of the lines of induction from end to end.

The effect of this is to get rid in great measure, though not completely, of the self-demagnetising influence of the bar's ends, so that the metal may be tested in a condition approximating to endlessness. The ends of the bar were sunk into holes bored for them in the yoke; one abutted against a fixed stop, on the other a plunger rested which was carried through the yoke, and could be loaded on top by means of a lever so as to produce a stress of compression in the bar.

The clear length of the bar between the inside faces of the yoke was 12·7 cms. Its area of section was 0·494 sq. cm., and that of the two sides of the yoke, taken together, was 51 sq. cms. The bar was wound along its whole clear length with a magnetising solenoid, through which currents of various strengths were sent from a battery of accumulators.

The magnetic induction was determined by reversing the current in this solenoid, and observing the transient current induced in an induction coil less than 1 cm. long wound at the middle of the bar.

The results can be stated here only very shortly. First a solid wrought iron bar was tested without compression, and then under a compressive stress of 226 kilos. per sq. cm.

Then the bar was cut into two parts at the centre and tested again, with and without the same load. Again it was cut into four parts, and finally into eight parts, and was tested with and without load in each case.

Each cutting caused a notable loss of permeability. The following are the values of the maximum ratio of magnetic induction ($\mathfrak{B}$) at the middle of the bar to the magnetising force due to the solenoid when the bar was tested without load:—

Solid bar	1220
Bar cut in two.....	930
Bar cut in four	640
Bar cut in eight	400

* Abstract of Paper read before the British Association Meeting at Manchester, September, 1887.

† *Proc.* Camb. Phil. Soc., Feb., 1887.

‡ Magnetisation of Iron, *Phil. Trans.*, 1885, Part II.

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The effect of loading was very remarkable. The curve of $\mathfrak{B}$ and $\mathfrak{H}$ in the solid bar is depressed by compressive stress with moderate values of $\mathfrak{H}$—that is to say, the bar is less susceptible to magnetisation under compression. The same effect is seen when the bar is cut in two. When the bar is cut in four, loading produces almost no change in the susceptibility, and when the bar is cut in eight loading produces a marked *increase* of susceptibility. Subjecting a cut bar to compression has two antagonistic effects on its magnetic permeability; it reduces the permeability by its effects on the solid portions; it increases it by its effect at the places of section; and, when these are numerous enough, the second or positive effect swamps the first or negative effect.

Next, another bar was tested (with and without load)—first when solid; then when cut at the middle into two parts, the cut ends being in the ordinary state as they left the lathes; and lastly, with the cut ends carefully faced up to the condition of true planes by scraping and comparing them with a standard Whitworth plane. So long as the bar was not loaded the magnetic susceptibility in the second or rough-cut state was much the same as in the third or faced-true state; in both it was notably less than before the bar was cut. But when the load was applied a remarkable difference was exhibited. The rough-cut bar, as in the former specimen with one cut, had its susceptibility reduced by compression; the faced bar, on the other hand, suffered no material change. The curves of magnetisation and field for (1) the rough-cut bar without load, (2) the faced bar without load, (3) the faced bar with load, and (4) the solid bar with load, are all nearly coincident. This result was confirmed by independent experiments with another sample.

When the ends of the cut bar were faced true the two effects of compression (by the particular load used in these tests) practically neutralised each other; when the bar was rough cut the negative effect was the stronger. The chief result of facing the ends is to augment the positive influence of the load. When loaded the bar with faced ends is, in fact, almost undistinguishable as to its magnetic permeability from the same bar in the uncut state.

The influence of a plane of section may be demonstrated by comparing the magnetic induction through and close to the plane of section of a cut bar with the induction in parts of the bar lying at some distance, by slipping an induction coil along the bar. In our experiments, however, this showed only a small part of the whole effect. A comparison of induction measured by means of coils placed at other parts of the length as well as at the middle of the bar, both before and after the bar was cut, showed that a single plane of section at the middle reduced the induction along the whole length to a remarkable extent, though its influence was of course most marked in the portions nearest to the plane of section.

The results make it highly probable that the effect of a plane of section in reducing the permeability of an iron bar is wholly due to a film of air between the cut faces. Using the method which Hopkinson has employed in predetermining the induction in dynamo cores, in which the line-integral of the magnetising force is equated with the line-integral of the induction divided by the permeability, we have calculated the thickness of air-film required to account for the defect of induction which we have observed. We find that when a cut bar is exposed to a magnetising force of 10 C.-G.-S. units, the air-film must have a thickness of only 0·028 mm. to explain the loss of permeability. And when the bar is cut into 4 or into 8 parts, the whole defect of induction is completely accounted for if we suppose each cut to introduce an air-film of about this thickness. Under stronger magnetising forces the thickness of the supposed air-film is reduced, as we should expect, so that when the magnetising force is about 50 C.-G.-S., the thickness of the film is only 0·014 mm., or half the above.

DISCUSSION.

Mr. GLAZEBROOK said he happened to have a proof of a paper on a similar subject by Prof. J. J. Thomson, and he might as well put the figures of the latter on the board, so that they might be compared with those of Prof. Ewing. In those experiments a bar of iron 10 cm. long was employed, which was cut in two; the ends were turned in a lathe roughly, then worked with a true plane as near as could be, and then Prof. Thomson made observations of the same kind as those of Prof. Ewing, separating the ends by one-hundredth of a diameter, two-hundredths, and so on. He would take one of the numbers on the board, referring with a magnetising force of 200, which he (Mr. Glazebrook) thought was stronger by four times than Prof. Ewing's. Taking that case only with a continuous core, the induction observed was 6,048. With the ends cut and turned in a lathe, then worked up to a true plane and pressed together with a wooden clamp, the induction came to be 5,472. With the ends turned as plain as they could be got the induction was 6,000, and with the ends separated by one one-hundredth of a diameter it was 5,328. Prof. Thomson said in the conclusion of his paper that the results were just as might be got if Green's expression were taken for the distribution of magnetism on a bar or cylinder placed in a uniform magnetic field.

Prof. PERRY: Was there iron connection between the ends?

Mr. GLAZEBROOK: There was no iron connection between the ends.

Lord RAYLEIGH: Is there any estimate of the air space required to explain the results?

Mr. GLAZEBROOK: There was no estimate.

Sir WM. THOMSON said what occurred to him as of some interest in connection with the physical properties concerned was that when the ends, pressed together, were not perfectly true the stress would be enormously deficient in different parts, and they knew that the effects of stress on magnetism were far from being in simple proportion to the pressure. Stress very intense in one part and not so intense in another would produce a very different effect from the uniform stress which existed in different parts of the iron. That, no doubt, would produce some complication in estimating the effects of stress which Prof. Ewing described. One question which he would like to ask was, was there any effect of instability, or anything to prevent the effect of instability?

Prof. EWING: As a matter of fact the bar was enclosed in a paper tube, which was enclosed in a solenoid of thick wire. It was perfectly stable.

Sir WM. THOMSON said it would be exceedingly interesting if Prof. Ewing would, with his apparatus, repeat the experiment, introducing a thin film of gold leaf. He (Sir William Thomson) had almost no doubt the result would be negative, but still it would be satisfactory just to know whether magnetic contact between iron and iron was or was not necessary. There was one other little point of interest. Was it possible to have in air or in gold leaf such an exceedingly intense field as 50,000 C.-G.-S! The field of the so-called induction—that was to say, the magnetic force on an ideal of the unit of the pole in a slot perpendicular to the lines of force, had been raised to a value not far from 50,000 in some of Prof. Ewing's experiments, by far the greatest figure ever attained. He had on a previous occasion inadvertently said that luminiferous ether had nothing to do but transmit light, but it must also be capable of exhaustion of energy at the rate of 50,000 times 50,000, 2,500 million C.-G.-S., or 2,500 million ergs. per centimetre, so that if there was to be any kinetic theory of the ether whatever, which was to be anything more than a mathematical abstraction, it must be shown to be capable of having its energy reduced or exhausted at the rate of 2,500 million C.-G.-S. per cubic centimetre. There was something very interesting indeed in estimating the extreme limits of magnetic force actually obtained. They had a limit of magnetisation in iron. Had they or had they not an absolute limit to the amount of magnetic force transmissible through air or gold leaf or a vacuum? He thought to solve that question would be splendid work.

Prof. SILVANUS THOMPSON asked if Prof. Ewing had tried whether after the diminution of the pressure the film of air left between the two pieces of iron remained in a good magnetic state. The question was a little important to those who built dynamos, for it made a very great difference in the making of the magnetic circuit. It might be well to put dynamos together under pressure, unless the film between the pieces could be put back again.

Prof. WIEDEMANN said it would be very interesting to remember an experiment made in the beginning of the century. The experimenter, when magnetising an iron or steel bar by drawing a magnet over it, put a very thin film of oil over the bar. He could not then get magnetisation. When he took off the oil the bar was immediately magnetised.

Mr. A. P. TROTTER said that this was a very important matter for dynamo makers. He had found in calculating the magnetic resistance of the field-magnets of dynamos that the resistance of the joints had to be allowed for. He had endeavoured to reduce this resistance to a minimum by accurately working the surfaces by scraping and the use of surface plates. A considerable amount of high-class workmanship had been expended in this direction, with the hope that the resistance of the joint would be reduced. When the question arose in the design of a new machine as to the probable effect of increasing the number of joints, an experiment was tried to determine the resistance. The upper bar of an inverted single horseshoe was separated from the side bars, first by the thickness of a sheet of paper, then by greater distances up to an inch. It was found that the increase of resistance was simply proportional to the distance, being merely the resistance of the air. No rapid decrease was found, as was expected, when the distance was small, and hence it was assumed that special pains in accurately surfacing the joints were not required. From knowledge of the resistance of the different qualities of iron employed he found the resistance of a joint between wrought iron and wrought iron to be equivalent to about 8 inches run of bar of the area of the joint. The same value was assumed for wrought iron and cast iron, and he had found that letting the end of a bar of wrought iron into a well fitting hole of a depth equal to its diameter produced no perceptible diminution of the resistance of the joint. Considering the large surfaces with which the dynamo maker had to deal, compared with the area of the bar used by Prof. Ewing, and the great force which was found necessary to produce perfect magnetic contact, Mr. Trotter was of opinion that it was useless for the dynamo maker to hope to introduce any improvement in this direction, either by accurate workmanship or by tightly screwing the bars together. Dynamo makers

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were none the less indebted to Prof. Ewing because this knowledge was of a negative character, for it would leave them with one less direction in which to work in improving their machines.

Lord RAYLEIGH asked Prof. Ewing if he had rightly understood him as to the thickness of the film necessary to explain the magnetic effects of a joint. It seemed to him from the figures given that it would come to about one thousandth of an inch. One could hardly suppose that two reasonably good surfaces in contact would be separated by such resistance as that. It was about forty wave-lengths of light.

Mr. R. P. SELLON said, with regard to the necessity for true joints, speaking as a practical dynamo builder, he thought the explanation of the fact that in dynamos they were not able to find any material difference if the surfaces were very smooth or tightly clamped together, was that the whole resistance between the magnetic limbs and the frames or yokes of the dynamo was very small indeed when compared with the resistance between the pole-piece and the armature. In the case of the Brush machine, he had actually tried the experiment of loosening or slackening away the bolt which held the magnetising limb on the frame, and there the limb was simply dependent upon a single bolt; but he had found that it was possible to slip away the bolt very materially indeed, so that one might imagine that there was a film of air between the surfaces.

Mr. ESSON said it was evident from Prof. Ewing's curves that the difference made in the permeability by increasing the pressure between the joints depended entirely upon the degree to which the magnet was saturated; whereas the difference at the beginning of the curves with low degrees of saturation was quite conspicuous, when the magnet was pretty well saturated the difference was inconsiderable. In dynamo machines they worked with the magnets fairly well saturated, and the working of the joints to a true plane consequently became a matter of small importance. The advantage to be derived from such nicety of workmanship would not nearly compensate for the extra work involved.

Mr. LOVE said the method he had adopted had been by using a circle of iron, so as to get as good a contact as he could. After doing that he had experimented to find the permeability of the iron—first, when the ends were firmly pressed in contact, and after that, when they were separated by known intervals. The resistance of air-space thus made was proportional to its length. Then, with regard to Prof. Ewing's curves, he had made an experiment in which he got an air-space of about a quarter of a millimetre wide. That seemed to answer pretty much to Prof. Ewing's calculation of the value of air-space in the place where he cut his bar into eight pieces. As far as he could see, looking at the curves from the position in which he was standing, his curve was almost exactly identical with Prof. Ewing's in every respect with regard to shape, and, as far as he could remember, as regards height, too. But between zero and the lowest part of the curve, for inductions of 0 to 2,000, the curve entirely changed in shape, becoming concave upwards.

Prof. FITZGERALD said, with reference to the remark of Lord Rayleigh, that it was true that two pieces of glass could be put together with facility, so as to leave an air space of no more than a few wave-lengths. He thought at the same time that anyone experimenting with flat pieces of glass without the application of pressure would not reduce the air-space to so small an amount by any means. It was necessary to apply very considerable pressure before the layers of air would be squeezed out from between them. It was also necessary to take great care in treating the surfaces of glass if they did not want particles of dust to remain between them. He would like to ask Sir William Thomson why he did not in his paper on the previous Thursday lead them to expect an energy per cubic centimetre of 1,000 million million million units? Possibly the remarks he had made that day were intended to lead them up, so that they might not be frightened by the enormous number he was going to mention afterwards.

Prof. EWING, in reply, said Sir William Thomson had asked whether there was any evidence of a limit to the possible number of lines of force per square centimetre of air, and what was the highest number that had been reached. The greatest number of lines of force in air Mr. Low and he had obtained was between 25,000 and 26,000 per square centimetre. There was nothing whatever to indicate that there was any serious difficulty in getting as many more as might be desired. If there was any physical object in forcing more lines into air to see how far they could go, no doubt they could do it with a slight modification of their present apparatus. Prof. Silvanus Thompson asked whether the film of air between the carefully-faced surfaces reappeared after the stress was removed. In their experiments it did so, but that might have been due to the fact that they always gave the bar a strong magnetic shaking up before measuring the induction. Each measurement of induction was made by reversing the magnetic state of the bar, and, in order to get rid of previous magnetisations, they reversed the magnetism many times before each reading. Of course this must have given the bar a powerful magnetic shaking up, and he had no doubt that would be of itself sufficient to account for the reappearance of the film of air. Mr. Trotter had referred to the application of this matter to the joints in dynamos, between yokes and cores and so forth. Curiously enough there appeared to have been for some time a very general impression in the minds of dynamo makers that there was a surface resistance to magnetisation. He had come across this impression even before Prof. J. J. Thomson's discovery was published, and he was at first inclined to regard the impression as an incorrect one, but it was not so; it was perfectly correct that there was a surface resistance, probably due to the distance between the metallic surfaces. But, as Mr. Sellon had pointed out, this was not a matter of much moment in a dynamo, simply because in another part of the magnetic circuit there was a great deal of air space, and putting a little more at the joints did not make any material difference. Lord Rayleigh referred to the difficulty that such an interval as they were obliged to assume seemed greater than was likely to occur in ordinary joints. He was sorry they had as yet made no attempt to measure the interval directly. He hoped to do so, and to make microscopical measurements as to the interval. He thought they might anticipate such an interval as the 35th or 70th of a millimetre when they considered the process of finishing a bar in a lathe. The end was not properly a plane at all, it was always more or less a cone, so that contact took place between two parts of a cut bar either on a circular ring near the outside or on a small circle inside the bar, and the area of that contact was no doubt materially increased by compression; but still, as these experiments seemed to show, the mean distance was not very much diminished by the compression. As regards the question—whether such a distance between the surfaces could exist in a truly faced plane, he thought they had a good deal of independent evidence that such a distance might be looked for. In the experiment of floating one Whitworth plane upon another, unless they squeezed them and gave them time they would find a marvellously small amount of friction, showing, in fact, that there was a very sensible air film between the two, which was only gradually expelled. Here, again, it might be imagined that the film would have vanished in these experiments, since the pieces were in contact for a considerable time; but he thought the film might have been caused to re-appear by the magnetic shaking which the bar got just before the test was made. Another speaker referred to the form which those curves would take if the experiment were made between zero induction and low values of induction. It was quite true that there they would expect by the air film theory—at least they would expect—the difference between the cut bar and the solid bar to become very much less simply because the permeability of the iron was very much less. He ought to have said that Prof. FitzGerald had anticipated him in answering Lord Rayleigh's question.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the discussion on Prof. Ewing's paper "On the Influence of a Plane of Transverse Section on the Magnetic Permeability of Iron," it did not occur to me that the observed resistance of the joints may be expressed by a certain thickness of air. Mr. Ravenshaw has pointed this out to me. The equivalent resistance to eight inches of iron is one ninetieth of an inch of air.

It is quite certain that this is far greater than the mean distance between the surfaces of a well-fitted joint, and this shows that the magnetic resistance is due to some other cause than the presence of a film of air.

The same reasoning may be applied to Prof. Ewing's experiments.—Yours, &c.,

ALEX. P. TROTTER.

Halifax, Sept. 10, 1887.

HISTORY OF THE WESTINGHOUSE TRANSFORMER.

A very interesting letter on the history of the transformer in the United States has been addressed by Mr. W. Stanley to our contemporary *The Electrician and Electrical Engineer*, of New York. Mr. Stanley says:—

It is not my purpose to write of the electrical problems which have been solved, but simply to narrate the practical developments in which I have been interested. Nor do I wish to claim for myself all the credit for what has been accomplished.

In August, 1884, while measuring the vacua of my incandescent lamps with an induction coil, I noted the relation between the quantity of current absorbed by the primary circuit, and that abstracted from the secondary coil, when the external resistance of the secondary circuit was varied. I found that the ohmic resistance of the primary coil (a thick, short wire) was insufficient in itself to account for the difference of potential maintained at its terminals, and that the *apparent* resistance of this coil varied coincidently with variations of resistance in the secondary circuit.

As these phenomena were analogous to the counter E.M.F. developed by an electric motor, and as they varied in a precisely similar way, I used the term counter E.M.F. at that time to express the reactive effects observed. The relation of this counter effect to the applied E.M.F., and particularly its value as an immaterial variable resistance, I explained at the time to a number of my friends, and shortly afterwards undertook the formation of a system of distribution, having a high difference of potential in the main circuit and induction coils, or converters, as I called them, with which to reduce this difference of potential. My first endeavours were to apply a direct current to a converter wound with a double primary circuit, having an automatic switch to shift the applied E.M.F. from one coil to the other, together with various short-circuiting devices, intended to produce a variable field around the primary and secondary circuits; all these devices proved to be impracticable. My next endeavour was to employ an alternating generator and converters arranged in series in a manner similar to the system of Messrs. Gaulard and Gibbs, of which, however, I knew next to nothing. These coils at first caused much trouble from want of regulation, but I found that, *by saturating the core*—that is, by making the number of ampere-turns sufficiently

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great and the self-inductive capacity relatively small—I could obtain excellent self-regulation on a constant current circuit. This system, however, wasted a large percentage of the energy applied, and was therefore abandoned.

In my next experiments I used the parallel system of distribution, and immediately found all the previous obstacles removed.

The parallel system, the usefulness of which appears to have first been suggested by Mr. Kennedy (although his experiments were unknown to me when I began work in the same direction), is the natural sequence of any experimental work with the series system; for, as I found, if all the converters had their primary circuits in series, and their secondary circuits connected in parallel, then applying a constant E.M.F. to the primary circuit, a constant difference of potential was obtained from the secondary circuit. The experimental proof of this proposition at once developed the utility of such a system, and the construction of the necessary apparatus for generating and transforming currents of high potential required but the application of previously acquired knowledge.

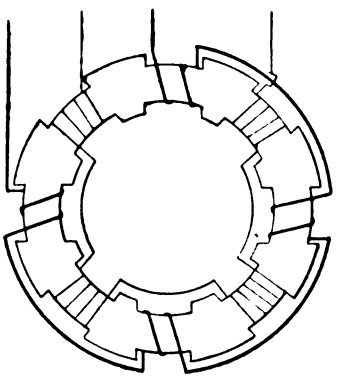

Fig. 1.

In working out a commercial transformer, I began with the Faraday ring type. By adding projecting lugs or teeth, as in a Gramme [Pacinotti] armature (Fig. 1). I somewhat reduced the magnetic resistance. I then applied internal and external rings (see Fig. 2), to reduce the length of the magnetic circuits; this form, however, was inconvenient to construct, and was abandoned almost immediately in favour of the type at present used (Fig. 3), [see also detailed description in *The Electrician*, Aug. 26, 1887], which is a development of the Gramme ring type of converter, for it is simply one coil of a Gramme ring with its inner and outer sheathing of iron.

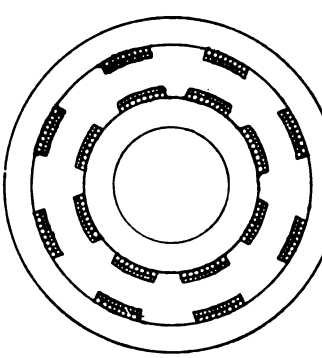

Fig. 2.

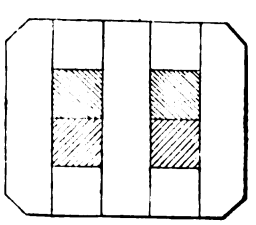

Fig. 3.

In the fall and winter of 1885 I established a central lighting station, employing these converters, at Great Barrington, Mass. This, I believe, was the first station in America operated on the induction system. We fed about 150 incandescent lamps on a circuit of No. 6 (B. and S.) wire, the circuit being nearly a mile in length. The lamps were largely used in the village stores and for general lighting. So successful was this attempt that the Westinghouse Electric Company immediately undertook the construction and installation of a large number of stations upon the same general plan.

The advantages obtained by a double conversion system are very great. In such a system the cost of the conductors, and, more important still, the loss of potential in the line, even for very long distances, may be substantially disregarded. In order to do away as nearly as possible with the loss in conversion that is due to what may be termed magnetic friction I have designed a system which I believe to be entirely novel. In this I employ what I term "auto-converters," viz., converters or transformers, each consisting of a single coil only.

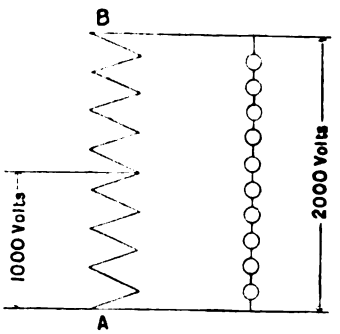

Fig. 4.

Fig. 4 shows one method of raising the potential by means of the "auto-converter." A B is a converter consisting of a single coil. It is evident that one-half of the coil acts to the other half as the primary of an induction coil to its secondary, and the potential between A and B is constant and is double that of A C. Fig. 5 shows an auto-converter for reducing the potential economically, *i. e.*, with less loss than with a double coil transformer. At intermediate points C' D' E' of the single coil A' B' loops are left out from the coil, and from these loops service wires are run, between which translating devices are connected in parallel in the usual manner.

It is evident that if the resistance between adjacent loops is equal, the arrangement becomes a series multiple coupling, and the coil A' B' has no work to do, and consequently there is no loss due to conversion. If, however, the resistance between any two adjacent loops is varied, say, for instance, increased, then that portion of the coil A B included between those loops acts as a primary to the rest of the coil, and the potential difference between all the loops remains constant. From this it will be seen that the coil acts to supply an induced current only to such resistances in any loop as are less than the resistance of the neighbouring loops, and therefore the loss due to conversion is simply that due to the conversion of the current flowing through the algebraic sum of the resistances of the separate loops.

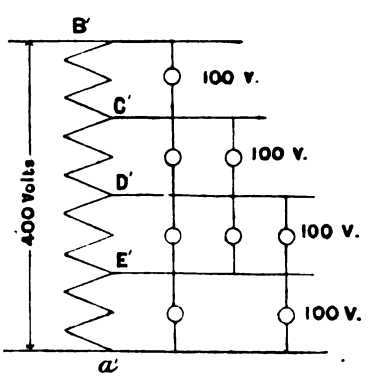

Fig. 5.

This form of converter possesses the same merit in potential distribution that the three-wire system does in the direct system. The real value of the induction system lies in the fact that by it potentials may be varied, raised or lowered at will, in the majority of cases with an accompanying loss of less than 2 per cent., and in many cases with no loss at all. If it were generally understood that the potential applied to a coil is simply distributed over its entire length at an equal voltage per unit of length, and hence that to obtain any desired E.M.F. it is simply necessary to tap off an equivalent length from the coil, the practical applications of the self-induction coil would be far more numerous than they now are.

There is a general misunderstanding to the effect that the

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alternating system of distribution in this country is, in its details, the invention of Messrs. Gaulard and Gibbs. None of the apparatus now used, however, was either designed or invented by them, nor is the system of distribution employed in connection with two or more converters the series system employed by these gentlemen.

But while the credit of the alternating inductive system, which has now become a commercial success in the United States, cannot be given entirely to Gaulard and Gibbs, their labours have, nevertheless, been most valuable, in that by their persistent efforts towards the practical application of induction coils in electric lighting they have drawn the attention of electricians generally to the subject, and thus paved the way for the new departure in electric engineering.

THE SUPPOSED "NEW FORCE."

BY R. C. SHETTLE, M.D.

(Continued from page 361.)

SPHEROID No. 4.

The wire on spheroid No. 3 was removed, and one half—*i.e.*, 26 strands—reapplied to one half of the surface—*i.e.*, to one half of each hemisphere, on the same side of the spheroid; these wires were laid on with the same description of helical turns as in Nos. 1, 2, and 3, the terminals being taken respectively to the seat of a

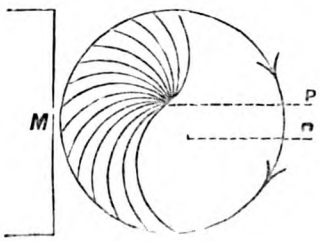

FIG. 8.

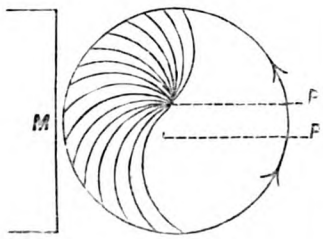

FIG. 9.

north and south magnetic poles on the same side of the sphere. These wires also were secured in position by means of thread.

Experiment 18.—The spheroid was subjected to the influence of the north pole of the electro-magnet just as before. Axial rotation was set up on making battery contact, but only through a limited area; upon making and breaking contact a complete axial rotation, first in one and then in the other direction, could be established.

Experiment 19.—A more precise examination of the motions of No. 4 spheroid showed that the direct and inverse currents had different effects according to the position of the object. Thus, when the spheroid was placed with the terminals of the wires on the left side of the magnetic axis of force (as shown in Fig. 8), the bulk of the wire being on the side of the sphere nearest the magnet, the direct current caused motion to the left, the pole P coming round to P′; but the inverse current in the same position of the sphere caused motion in the opposite direction (see Fig. 9), the pole P coming round to P′.

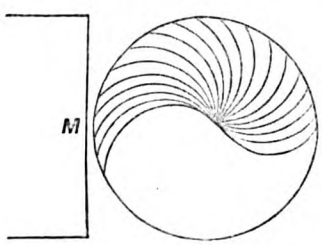

FIG. 10.

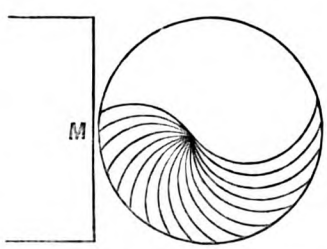

FIG. 11.

Experiment 20.—The direct current when the spheroid was as shown in Fig. 10 was slight, but to the right. The inverse current in the same position of the spheroid caused rapid motion to the right, and brought the poles round to the position shown in Fig. 11.

SPHEROID No. 5.

The surface of a 3in. wooden sphere was divided by an equatorial line into two hemispheres. The central spot on each hemisphere was marked and called a geographical pole; a circle two inches in diameter was drawn round each polar spot, and called a polar circle. The surface was next divided by parallel lines of longitude into six equal parts. The points where the three alternate lines crossed the polar circle were marked, and designed for the seats of three magnetic poles. The intermediate lines of longitude were marked at the point where they crossed the equatorial line. Pins were next driven into each of these nine points, and the sphere was ready to receive its wire coating.

The wire (No. 16 cotton-covered) reached from one of the points on one polar circle to the opposite point on the other circle, taking a diagonal direction from one point to the other, so as to include one of the pins where the next longitudinal line crossed the equatorial line. The terminals and equatorial point were fixed by india rubber insulite. Other pieces of wire were then adapted to the portion already laid on as described, the terminals of each being brought to the same point, until the V shape had been quite filled in its concavity. This plan was adopted for each of the three centres, and is shown in Figs. 12 and 13, 12 being the equatorial, and 13 the polar view.

For the purpose of suspending this spheroid so as to expose a variety of inclinations to the axis of the electro-magnet, loops of whalebone were driven into the points marked with dots on Fig. 13, viz., one at the seat of the geographical pole, and five others between this and two of the magnetic poles.

Experiment 21.—Sphere No. 5 was subjected to the influence of the electro-magnet by being suspended first from the geograp hical pole. Upon making battery contact, axial rotation through about 45deg. was set up; but the motion was very slow, and only occurred after some few seconds of exposure.

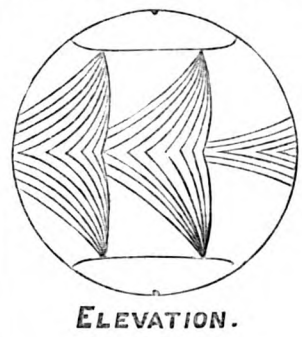

FIG. 12.

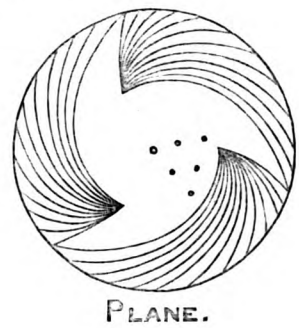

FIG. 13.

Experiment 22.—The inclination of the sphere was changed, the point of suspension being now close to one of the polar points. On making battery contact, axial rotation was quickly set up, and the motion was much more rapid than in Experiment 21, especially as the pole nearest to the electro-magnet was brought more immediately into the axis of force. By maintaining contact the pole nearest the magnet oscillated, and then tended to come to rest opposite the electro-magnetic pole.

(To be continued.)

SCIENTIFIC LECTURES AT THE NEWCASTLE EXHIBITION.

On Saturday last Prof. Garnett again lectured on the electric light in the theatre of the Newcastle Exhibition. A frame was erected on the stage, from which were suspended two arc lamps constructed by Messrs. J. H. Holmes and Co., of Newcastle, two diamond arc lamps employed by Messrs. Woodhouse and Rawson in lighting the garden of the Exhibition, and an incandescent lamp of 600 candle-power constructed by Messrs. Clarke, Chapman and Parsons, of Gateshead. By the side of this frame was an incandescent search light of 500 candle-power lent by the last mentioned firm and employed by ships in entering docks or harbours at night. This light was used on the occasion in question to illuminate some of the darker objects on the stage. A reflecting galvanometer served to show the production of a current in a coil of wire moving near a steel bar magnet by means of a disc of light on the magic lantern screen, and a few magic lantern views and a hand Gramme machine served to illustrate the construction of the dynamo. One of the prettiest exhibits was a small arc light, constructed by Messrs. J. H. Holmes and Co., and burning steadily with a current of two amperes. The lamp was connected in series with two small glow lamps, so arranged that the two absorbed exactly the same amount of energy as the arc lamp, while the light produced could be compared by the audience. On a small drawing room table in front of the stage stood a turbo-electric generator having an output of about 5 electrical horse-power, and lent by Messrs. Clarke, Chapman and Parsons, of Gateshead. Below it were placed the armature, spindle, and one-half of the barrel of a large generator, intended for an Atlantic steamer, and having an output of nearly 40 electrical horse-power. This generator is constructed on the triple expansion principle, the steam, in passing from the centre to either end of the barrel, having to

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make its way through three sets of turbines of increasing dimensions.

The lecture commenced with a description of the arrangements for the lighting of the theatre, and for raising and lowering the lights as required for stage effects. Three times the theatre was put into darkness as though an accident had happened to the machinery, and on each occasion one of the "panic circuits" was switched on either from the stage or the ticket office outside. One of these panic circuits contains an incandescent lamp of 1,000 candle-power constructed by Messrs. Clarke, Chapman, Parsons and Co., and it was surprising to notice how well the large building was lighted by this lamp alone. All the rest of the arrangements for the lighting of the theatre have been carried out by Messrs. J. H. Holmes and Co., of Newcastle, whose "panic circuit" is connected with the picture gallery lights quite independent of all the other lamps in the theatre. The account which we have given of the apparatus on the stage will convey to our readers a fair idea of what the rest of Prof. Garnett's lecture comprised. There was a full house, the audience consisting largely of working men. Arrangements have been made for scientific lectures every Monday and Saturday evening until the close of the Exhibition.

ELECTRIC LIGHTING FROM CENTRAL STATIONS.*

I.—Electric Lamps.

If I use a galvanic battery or a dynamo machine as a source of electricity, and connect its poles by a metal wire, an electric current flows through the wire. If I break the wire at any point, the current ceases to flow. If part of the wire be wound round a bar of iron, a noise is heard, and a bright momentary flash is seen at the instant of breaking the circuit. If the iron bar be U-shaped so as to form an electro-magnet of the usual type with poles, then by causing the rupture of the wire to take place between the poles I can increase enormously the noise and momentary character of the flash.

If, on the other hand, the wire be not coiled and has no iron near it, the act of breaking the wire does not give rise to noise, and the flash is not so instantaneous; in fact, the flash can be rendered permanent by holding the two broken ends at a short distance. I am now using a copper wire. I hold the ends at a distance of one eighth of an inch, and you see a steady green light. I replace the copper by iron, and you see a redder colour. Again, if I use zinc the colour is blue. In each case the heat developed suffices to melt the metal and evaporate it, and the distinctive colour is given off only when the metal is in the form of vapour.

Carbon in the form of charcoal, however, does not melt or evaporate even at a very high temperature. When now I use two charcoal rods in the part of the circuit which I break, we have the brilliant white incandescence of a solid body at the highest attainable temperature. This is what is generally known as the arc light. It was discovered by Sir Humphry Davy at the beginning of the century. Since that time the ingenuity of inventors has led to the introduction of numerous devices for maintaining the distance of the carbons constant. One of the most successful of these inventions is the lamp of Messrs. Brockie and Pell, which I have here, and whose steady bright silent light must please the most critical eye. I throw an image of the carbon points on the screen. You notice that from the carbon connected with the positive pole of the battery particles fly off, and it becomes hollowed into a white crater of brilliant incandescence. On the negative carbon a pile of carbon is heaped up. Both carbons are meanwhile being consumed by the oxygen of the air. Hence a feeding action is required to maintain a constant distance between the points. This is regulated by a simple mechanism, and we have a practical lamp suitable for street lighting, and for the illumination of workshops and large halls or open spaces.

But it is not necessary to sever the metallic conductor in order to get intense heat and light. No substance is a perfect conductor, and the energy of the electric current is partly used up in heating the materials through which it passes. I pass the current through a platinum wire. It glows with intense heat. I increase the current, and the incandescence of the wire is white. I have chosen platinum because the temperature of melting is high, and it is not consumed by the oxygen of the atmosphere But even platinum has a melting temperature, and now when I increase the current still further it melts and the source of light has broken down.

The radiant energy of this wire consists partly of heat rays which are invisible to our eyes, and partly of visible rays. The higher the temperature the greater is the proportion of visible rays. Thus by choosing platinum with its high melting point we have chosen an economical source of light.

Carbon, however, has a higher melting point, and we can obtain fine threads or filaments of carbon. It must therefore be economical. Here I have such a filament exposed to the air. I pass a current through it. It gives a brilliant flash for a second, and is consumed by the oxygen of the atmosphere. Clearly we must remove this defect. I have a similar filament in a glass globe full of nitrogen gas, and now the filament shines as the current goes through it. Of course you would expect the heat to be used up by contact with the nitrogen gas setting up convection currents and cooling the filament. Let us see if this is the case. Here I have an exactly similar filament in a similar glass bulb from which all trace of air or gas has been, so far as possible, exhausted. I pass the same electric current through both. The one with nitrogen gas is dull, the one in vacuo shining with marvellous brilliancy.

This last is the incandescent lamp of the present day, whose mellow light is so pleasing to the eye. It is safe, cleanly, and healthy. Safe, because it cannot set fire to inflammable objects and cannot explode like gas; cleanly, because it has no noxious gases to tarnish silver and decorations; healthy, because it does not pollute the atmosphere, and does not heat it as gas does. Its safety has been shown by the action of the municipality of Paris, who, after the burning of the Opera Comique by gas, ordained that all theatres are to be lighted by these electric lights. Its good qualities are proved by the fact that every one who has the means furnishes his house with this light, and by the fact that the public are crying out at the action of Parliament in hindering the public supply of electricity by legislation in support of the gas monopoly.

You have now seen two methods by which electricity can be utilised for producing the electric light—the arc and the incandescent systems. I do not know of any other that is possible, except that perhaps in the future the brilliant discoveries of Mr. Crookes may be turned to practical account. That eminent investigator has discovered that if an electric current be passed through a glass tube or bulb nearly emptied of air, and if certain substances be placed in the glass bulb, they shine with a brilliant light. You are aware that some substances are said to be phosphorescent, which means that after having been exposed to a powerful light they shine in the dark. I have here six bottles, each containing a different fluorescent substance. I illuminate them for a few seconds by holding them before the light of burning magnesium, and now on darkening the room they give off a feeble light. Visionaries have been known who hoped that some day our houses will all be painted with some such substance, so that the solar energy stored up in the day may return to us a general illumination at night. In the meantime we know that by subjecting such substances to the electric current of great pressure which we get from the induction coil, they do, if enclosed in a nearly perfect vacuum, give off a light far more brilliant than the phosphoresence you have just seen. Through the kindness of Dr. De la Rue, I am able now to show you such brilliant effects, and you will observe that while I am using up the feeble amount of electrical energy supplied by this induction coil, I am producing an illumination which lights up all the objects in the neighbourhood.

We have, however, at present no practical application of these brilliant discoveries of Mr. Crookes.

II.—Generators of Electricity.

Having now glanced at the lamps at our disposal for utilising the electric current, viz., the arc lamp for streets and large halls, and the incandescent or glow lamp for interiors of dwelling houses, let us glance for a moment at the means which we have at our disposal for generating the electric current. There are in general use two ways of generating this kind of energy; the first by transforming chemical into electrical energy, the second by transforming the mechanical energy of water, steam, &c., into electrical energy. The loss in either case need not amount to more than 10 per cent. The apparatus which utilises chemical action is called a galvanic battery, or simply a battery. The best of these are secondary batteries in which, when the chemical energy is used up, it can be restored by charging with those machines which convert mechanical into electrical energy. We have several excellent secondary batteries, the best I know being that called the Union Battery. The Electric Power and Storage Company, and Elwell-Parker both supply a good secondary battery which has long stood the test of experience. Any one of these batteries has two terminals, to which the ends of an electric circuit can be attached, and then an electric current flows through the circuit. When the battery is exhausted, a current is sent through it in the reverse direction, and it is renovated.

All the machines at present used for converting mechanical into electric energy are founded on the discovery of Faraday that by moving about a coil of wire in the neighbourhood of a magnet, an electric current can be started in the coil. The same coil will experience a force tending to move it if an electric current flows through it while it is in the neighbourhood of a magnet. A machine constructed on this principle is usually called a dynamo machine, and it can be used either to convert mechanical into electric energy, or *vice versâ*. I will now show by the aid of the lantern a model of such a dynamo running as a motor when an electric current is passed through its coils.

I do not wish to waste your time by showing the details of dynamo machines. A dynamo contains generally four special parts:—(1) Pieces of iron with insulated wire coiled round them. These are called field-magnets, and are fixed in the framework of the machine or else form part of it. (2) Revolving coils of insulated wire. These form what is called the armature. (3) A commutator consisting of a number of bars of metal connected to the coils and revolving with them. (4) Two wire brushes fixed to the framework, rubbing against the commutator bars. To these last are attached the ends of the conducting circuit through which a current is to flow. Part of the electric energy is generally diverted through the wire coils on the field-magnets so as to magnetise them. The object of the commutator is to convert the electric current, which is reversed in the coils at each half rotation which they make, into a continuous current in the external circuit.

I now throw on the screen an end view of such a dynamo, and you will observe the field-magnets and brushes which are fixed. But by turning a handle you now see the central armature and the commutator on which the brushes rub rotating continuously. You can recognise these four parts in any of the ordinary dynamos. Sometimes, however, there is no object in having a continuous current in the external circuit, in which case the commutator is dispensed with, and the two ends of the wire coils in the armature are connected to two metal rings on and concentric with the spindle. The brushes rubbing on these lead to the external circuit a

* A lecture delivered by Prof. George Forbes, M.A., F.R.S., to working men at the Manchester Meeting of the British Association, September 3rd, 1887.

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current which is reversed in direction at each passage of the armature coils from one pole of the field-magnets to another. Such machines are called alternating current machines.

With a suitably-constructed dynamo and an economical and reliable steam engine, an electric current can be generated cheaply without fear of failure.

III.—Distribution of Electricity.

We now understand the apparatus by which we obtain the electric light. The next question is how to supply a number of lamps from one engine room. I place a number of lamps in a long chain, so that the same electric current passes through all of them. This is what is called a series arrangement. It has a disadvantage. Suppose one of the lamps be broken, what happens? It breaks the electric circuit. I break one of these lamps placed in series, and all the others are extinguished; there is no longer a complete conducting circuit through which the current can flow. Mr. Edison has used another plan. He leads two wires from the two poles of the machine all over the district to form the main conductors, and wherever he has a lamp he leads two wires from it to the main conductors. A complete circuit is then offered for the current to pass along, and the lamp is luminous. Then I have Edison's parallel system. You see the main conductors to which ten lamps are attached in the way I have described. Now I break one of them, but the others are not affected. This plan is very simple to work, but it is not suitable for carrying the current to a distance, as I will presently explain.

When I was asked to choose a subject on which to lecture to you, I felt that I should best be discharging my duty if I chose that branch of practical and applied science to which I have devoted the most attention. This subject is the means of distributing electric current to a large district from a central station. In this case a thin wire does not suffice to carry the large current required for all the lamps. Such a wire would get very hot, and more steam power might be used in heating the main conductors than in causing the lamps to shine. It is easy to calculate what size of conductor would be the most economical. I have here two great rods, each a foot in diameter, and this is the size required to supply a district with 100,000 lamps in the most economical way if the conductors were made of the best material, which is pure copper. You can see at a glance that the cost of some miles of such conductors would be prohibitive.

The great difficulty of an engineering character which was encountered in the early attempts to introduce central station electric lighting lay in the enormous cost of the copper conductors required to carry the current. This, as much as the Electric Lighting Act of 1882, was the cause of the abandonment of all the earlier schemes.

If we do not lay down thick conductors we suffer in two ways. First, the electric pressure is used up in the mains to such an extent that different consumers along the route of the mains do not get the same electric pressure, and the pressure at each house varies with the amount of light being used in other houses.

Secondly, there is a great loss of energy in forcing the current through the thin mains. By thickening the mains we increase our capital expenditure, but we reduce the annual waste of energy in the mains, and it is easy for the engineer to determine the most economical arrangement.

On doing this it was found that the cost was prohibitory for supplying large districts. Deeply interested as engineers were in the progress of electric lighting, no engineer of eminence supported these early and crude schemes.

The plan originally proposed was to lay positive and negative mains all over the streets, and to connect the lamps singly or in groups to these mains by wires. This can only be done economically in small establishments where the greatest distance of a lamp from the machine along the route of the conductors is little more than 200 yards. It is excellent for clubs, hotels, and country houses.

If we connect each pair of our lamps in series, so that the same current passes through both, the electric pressure must be doubled but the current is halved, and at once we have a reduction in the size required for the mains. The disadvantage of this is that if one of the lamps of a pair goes out or is put out, the other lamp of the pair also goes out, as you see when I try the experiment. Here are twelve lamps arranged in six pairs, and when I extinguish one of a pair the other goes out. Now, if I connect together by another wire all the wires connecting the pairs, you will see that when I extinguish one lamp there is still a course open for the current, and no other lamp goes out. I extinguish three lamps of three pairs, and still no other lamp goes out. But you do notice that the three top lamps are fed by the same amount of current as the six bottom ones, and are so much brighter. This is a serious disadvantage, but can be remedied by leading the middle connecting wire, which I just now introduced, to the middle of the battery or other source of electric energy which I am using. Now you see there is no difference in the brightness of the light, however many I may extinguish. This way of using three wires introduces a considerable economy in conductors, and extends the distance to which we can work economically to a quarter of a mile, as has been found from numerous trials, especially in America. This is generally called the three-wire system. This, however, still leaves us a long distance from central station lighting on a large scale.

The idea of using high electric pressure in the mains commends itself because it cheapens our conductors. We have doubled our pressure by using the three-wire system. Can we advance farther in the same direction? If we use 2,000 volts pressure instead of 100 volts (the ordinary pressure of a glow lamp), we reduce the copper in our conductors about 20-fold. But it is impossible to permit 2,000 volts pressure in houses where people might get shocks and be killed. It has been proposed to charge 1,000 cells of a secondary battery in series from a central station, and discharge them to a small district 50 cells in series. This would involve a storehouse for every quarter of a square mile or even less. The system would be very good were it not for the expense of secondary or storage batteries. This puts the matter at present out of the question. It may come in time. It has the enormous advantage of leaving the system in working order even when machinery gives way, and of storing up an unusual amount of energy for special occasions, such as a general illumination. At present there is only one system thoroughly worked out for using high pressure in the mains and low pressure in the lamps. It is founded upon Faraday's discovery of induction. When I send an electric current through a coil of wire which has an iron core, the latter becomes a magnet, and continues to be one so long as the current is continued. During the act of magnetising, a certain amount of work is done, and is stored up in the magnet. At the moment when the current ceases, this energy is re-stored by the magnet in the form of additional current. Here I have an electro-magnet with two iron limbs separately wound. The wire of one limb can be connected with an incandescent lamp; that of the other with a battery. I now pass a current through the wire on one limb. Next I connect the glow lamp to the wire of the other limb. I now break the electric circuit, and you see that the glow lamp in the second circuit glows for a moment. The energy stored in the magnet is given up to the glow lamp.

An induction coil consists of an iron core surrounded by two coils, one of thick wire, the other some miles long but of very thin wire. It also has a means for rapidly interrupting the electric current from a battery in the short thick coil. This magnetises and demagnetises the iron core. The iron core gives off energy to the long thin coil, and an intermittent current of very high pressure is set up in that wire. You see that long sparks flash through the air from one end of the wire to the other. I now pass the current thus obtained through a resistance equivalent to many miles of telegraph wire, and send it through the thin coils of induction apparatus at the other end of the room. This magnetises and demagnetises the iron core, and if I connect the thick coils of the distant apparatus with glow lamps you see them shine brightly.

Here we have a high-pressure current which can be sent over a distance of many miles through a thin wire, and then converted into the ordinary low pressure required for lighting purposes. The system to be perfect must be worked by a dynamo machine which gives a high-pressure current of electricity alternating in direction. The first person to use such an alternating current of high tension in the mains and convert it by means of efficient apparatus into a current of the ordinary pressure required for the lamps in a house was M. Gaulard. It is now being largely used both in Europe and in America. An engineer has the greater confidence in recommending this system because, if ever storage batteries become available, the same system of conductors will do, and no change need be made.

IV.—Main Conductors.

I must now say a word about the main conductors. These may be laid either overhead or underground. The former plan has most generally been adopted in England and America. In America, because the prime cost is less; in England, because the Electric Lighting Act imposes prohibitive conditions on underground conductors, but does not deal with overhead ones. For a permanent works there is no doubt that underground conductors are the best, and also the cheapest in the end if the contractors are not mulcted for the concession.

It has been said that no good system of underground conductors exists. This is sheer nonsense. The plan I will explain is not by any means the only one, but I believe it to be the cheapest and perhaps the most complete. It has also the merit, as a system to describe, of novelty.

Gas pipes are laid down in the ordinary way to serve as a trough for the conductors. Gas pipes are used because sixty years' experience has taught us what they will do, and made our workmen acquainted with them, and they cost little. Two porcelain discs in each pipe serve as insulators. They are pierced with three holes (say an inch diameter) for the three-wire system, and with more or less holes in other systems according to requirements. Through these holes are passed thin split copper tubes, which by springing out grip the porcelain insulators. Into the ends of these, the ends of additional lengths of split tubing are squeezed. Thus we get a long length of gas piping, with two or three or more insulated copper tubes. These copper tubes are not the conductors, but serve other purposes.

Manholes with sumps are provided at every cross street. Naked wire is drawn through the copper tubes, only as much copper wire being used as suffices for immediate wants. Additional wire can be added as consumers are added to the district. When a house is to be joined to any part of the mains, a hole is tapped in the gas pipe and wires soldered on to the copper tubes, and enclosed in a small iron gas-tube screwed into the main pipe. The number of wires can at any time be added to or diminished. When the tube is two-thirds full, it is difficult to pull more wire through. The old wires may then be removed and a bare cable of wire filling the whole tube drawn through.

I believe that in speaking to practical working men, as I am just now, I am addressing those who can appreciate the benefits of this system, which I have not time to dwell on more fully at present.

V.—Meters.

The only weak part of a system which uses alternate currents with induction coils, is that till lately no meter existed which would measure the consumption of electricity. I am glad to be able to illustrate the principles of a meter which now acts equally well for alternate and continuous electric currents. Here I have a spiral cut out of a circle of paper. It is supported on a point at its middle. A coil of wire is below it, and an electric current passes through the coil and heats it. Thus a current of air is set up by convection, which turns the paper spiral as you see clearly when it is thrown on the screen. A more perfect vane has been made, which you can also see at work by the aid of the lantern. A train of wheels and pinions is attached for counting the number of revo-

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make its way through three sets of turbines of increasing dimensions.

The lecture commenced with a description of the arrangements for the lighting of the theatre, and for raising and lowering the lights as required for stage effects. Three times the theatre was put into darkness as though an accident had happened to the machinery, and on each occasion one of the "panic circuits" was switched on either from the stage or the ticket office outside. One of these panic circuits contains an incandescent lamp of 1,000 candle-power constructed by Messrs. Clarke, Chapman, Parsons and Co., and it was surprising to notice how well the large building was lighted by this lamp alone. All the rest of the arrangements for the lighting of the theatre have been carried out by Messrs. J. H. Holmes and Co., of Newcastle, whose "panic circuit" is connected with the picture gallery lights quite independent of all the other lamps in the theatre. The account which we have given of the apparatus on the stage will convey to our readers a fair idea of what the rest of Prof. Garnett's lecture comprised. There was a full house, the audience consisting largely of working men. Arrangements have been made for scientific lectures every Monday and Saturday evening until the close of the Exhibition.

ELECTRIC LIGHTING FROM CENTRAL STATIONS.*

I.—Electric Lamps.

If I use a galvanic battery or a dynamo machine as a source of electricity, and connect its poles by a metal wire, an electric current flows through the wire. If I break the wire at any point, the current ceases to flow. If part of the wire be wound round a bar of iron, a noise is heard, and a bright momentary flash is seen at the instant of breaking the circuit. If the iron bar be U-shaped so as to form an electro-magnet of the usual type with poles, then by causing the rupture of the wire to take place between the poles I can increase enormously the noise and momentary character of the flash.

If, on the other hand, the wire be not coiled and has no iron near it, the act of breaking the wire does not give rise to noise, and the flash is not so instantaneous; in fact, the flash can be rendered permanent by holding the two broken ends at a short distance. I am now using a copper wire. I hold the ends at a distance of one-eighth of an inch, and you see a steady green light. I replace the copper by iron, and you see a redder colour. Again, if I use zinc the colour is blue. In each case the heat developed suffices to melt the metal and evaporate it, and the distinctive colour is given off only when the metal is in the form of vapour.

Carbon in the form of charcoal, however, does not melt or evaporate even at a very high temperature. When now I use two charcoal rods in the part of the circuit which I break, we have the brilliant white incandescence of a solid body at the highest attainable temperature. This is what is generally known as the arc light. It was discovered by Sir Humphry Davy at the beginning of the century. Since that time the ingenuity of inventors has led to the introduction of numerous devices for maintaining the distance of the carbons constant. One of the most successful of these inventions is the lamp of Messrs. Brockie and Pell, which I have here, and whose steady bright silent light must please the most critical eye. I throw an image of the carbon points on the screen. You notice that from the carbon connected with the positive pole of the battery particles fly off, and it becomes hollowed into a white crater of brilliant incandescence. On the negative carbon a pile of carbon is heaped up. Both carbons are meanwhile being consumed by the oxygen of the air. Hence a feeding action is required to maintain a constant distance between the points. This is regulated by a simple mechanism, and we have a practical lamp suitable for street lighting, and for the illumination of workshops and large halls or open spaces.

But it is not necessary to sever the metallic conductor in order to get intense heat and light. No substance is a perfect conductor, and the energy of the electric current is partly used up in heating the materials through which it passes. I pass the current through a platinum wire. It glows with intense heat. I increase the current, and the incandescence of the wire is white. I have chosen platinum because the temperature of melting is high, and it is not consumed by the oxygen of the atmosphere But even platinum has a melting temperature, and now when I increase the current still further it melts and the source of light has broken down.

The radiant energy of this wire consists partly of heat rays which are invisible to our eyes, and partly of visible rays. The higher the temperature the greater is the proportion of visible rays. Thus by choosing platinum with its high melting point we have chosen an economical source of light.

Carbon, however, has a higher melting point, and we can obtain fine threads or filaments of carbon. It must therefore be economical. Here I have such a filament exposed to the air. I pass a current through it. It gives a brilliant flash for a second, and is consumed by the oxygen of the atmosphere. Clearly we must remove this defect. I have a similar filament in a glass globe full of nitrogen gas, and now the filament shines as the current goes through it. Of course you would expect the heat to be used up by contact with the nitrogen gas setting up convection currents and cooling the filament. Let us see if this is the case. Here I have an exactly similar filament in a similar glass bulb from which all trace of air or gas has been, so far as possible, exhausted. I pass the same electric current through both. The one with nitrogen gas is dull, the one in vacuo shining with marvellous brilliancy.

This last is the incandescent lamp of the present day, whose mellow light is so pleasing to the eye. It is safe, cleanly, and healthy. Safe, because it cannot set fire to inflammable objects and cannot explode like gas; cleanly, because it has no noxious gases to tarnish silver and decorations; healthy, because it does not pollute the atmosphere, and does not heat it as gas does. Its safety has been shown by the action of the municipality of Paris, who, after the burning of the Opera Comique by gas, ordained that all theatres are to be lighted by these electric lights. Its good qualities are proved by the fact that every one who has the means furnishes his house with this light, and by the fact that the public are crying out at the action of Parliament in hindering the public supply of electricity by legislation in support of the gas monopoly.

You have now seen two methods by which electricity can be utilised for producing the electric light—the arc and the incandescent systems. I do not know of any other that is possible, except that perhaps in the future the brilliant discoveries of Mr. Crookes may be turned to practical account. That eminent investigator has discovered that if an electric current be passed through a glass tube or bulb nearly emptied of air, and if certain substances be placed in the glass bulb, they shine with a brilliant light. You are aware that some substances are said to be phosphorescent, which means that after having been exposed to a powerful light they shine in the dark. I have here six bottles, each containing a different fluorescent substance. I illuminate them for a few seconds by holding them before the light of burning magnesium, and now on darkening the room they give off a feeble light. Visionaries have been known who hoped that some day our houses will all be painted with some such substance, so that the solar energy stored up in the day may return to us a general illumination at night. In the meantime we know that by subjecting such substances to the electric current of great pressure which we get from the induction coil, they do, if enclosed in a nearly perfect vacuum, give off a light far more brilliant than the phosphorescence you have just seen. Through the kindness of Dr. De la Rue, I am able now to show you such brilliant effects, and you will observe that while I am using up the feeble amount of electrical energy supplied by this induction coil, I am producing an illumination which lights up all the objects in the neighbourhood.

We have, however, at present no practical application of these brilliant discoveries of Mr. Crookes.

II.—Generators of Electricity.

Having now glanced at the lamps at our disposal for utilising the electric current, viz., the arc lamp for streets and large halls, and the incandescent or glow lamp for interiors of dwelling houses, let us glance for a moment at the means which we have at our disposal for generating the electric current. There are in general use two ways of generating this kind of energy; the first by transforming chemical into electrical energy, the second by transforming the mechanical energy of water, steam, &c., into electrical energy. The loss in either case need not amount to more than 10 per cent. The apparatus which utilises chemical action is called a galvanic battery, or simply a battery. The best of these are secondary batteries in which, when the chemical energy is used up, it can be restored by charging with those machines which convert mechanical into electrical energy. We have several excellent secondary batteries, the best I know being that called the Union Battery. The Electric Power and Storage Company, and Elwell-Parker both supply a good secondary battery which has long stood the test of experience. Any one of these batteries has two terminals, to which the ends of an electric circuit can be attached, and then an electric current flows through the circuit. When the battery is exhausted, a current is sent through it in the reverse direction, and it is renovated.

All the machines at present used for converting mechanical into electric energy are founded on the discovery of Faraday that by moving about a coil of wire in the neighbourhood of a magnet, an electric current can be started in the coil. The same coil will experience a force tending to move it if an electric current flows through it while it is in the neighbourhood of a magnet. A machine constructed on this principle is usually called a dynamo machine, and it can be used either to convert mechanical into electric energy, or *vice versâ*. I will now show by the aid of the lantern a model of such a dynamo running as a motor when an electric current is passed through its coils.

I do not wish to waste your time by showing the details of dynamo machines. A dynamo contains generally four special parts:—(1) Pieces of iron with insulated wire coiled round them. These are called field-magnets, and are fixed in the framework of the machine or else form part of it. (2) Revolving coils of insulated wire. These form what is called the armature. (3) A commutator consisting of a number of bars of metal connected to the coils and revolving with them. (4) Two wire brushes fixed to the framework, rubbing against the commutator bars. To these last are attached the ends of the conducting circuit through which a current is to flow. Part of the electric energy is generally diverted through the wire coils on the field-magnets so as to magnetise them. The object of the commutator is to convert the electric current, which is reversed in the coils at each half rotation which they make, into a continuous current in the external circuit.

I now throw on the screen an end view of such a dynamo, and you will observe the field-magnets and brushes which are fixed. But by turning a handle you now see the central armature and the commutator on which the brushes rub rotating continuously. You can recognise these four parts in any of the ordinary dynamos. Sometimes, however, there is no object in having a continuous current in the external circuit, in which case the commutator is dispensed with, and the two ends of the wire coils in the armature are connected to two metal rings on and concentric with the spindle. The brushes rubbing on these lead to the external circuit a

* A lecture delivered by Prof. George Forbes, M.A., F.R.S., to working men at the Manchester Meeting of the British Association, September 3rd, 1887.

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current which is reversed in direction at each passage of the armature coils from one pole of the field-magnets to another. Such machines are called alternating current machines.

With a suitably-constructed dynamo and an economical and reliable steam engine, an electric current can be generated cheaply without fear of failure.

III.—Distribution of Electricity.

We now understand the apparatus by which we obtain the electric light. The next question is how to supply a number of lamps from one engine room. I place a number of lamps in a long chain, so that the same electric current passes through all of them. This is what is called a series arrangement. It has a disadvantage. Suppose one of the lamps be broken, what happens? It breaks the electric circuit. I break one of these lamps placed in series, and all the others are extinguished; there is no longer a complete conducting circuit through which the current can flow. Mr. Edison has used another plan. He leads two wires from the two poles of the machine all over the district to form the main conductors, and wherever he has a lamp he leads two wires from it to the main conductors. A complete circuit is then offered for the current to pass along, and the lamp is luminous. Then I have Edison's parallel system. You see the main conductors to which ten lamps are attached in the way I have described. Now I break one of them, but the others are not affected. This plan is very simple to work, but it is not suitable for carrying the current to a distance, as I will presently explain.

When I was asked to choose a subject on which to lecture to you, I felt that I should best be discharging my duty if I chose that branch of practical and applied science to which I have devoted the most attention. This subject is the means of distributing electric current to a large district from a central station. In this case a thin wire does not suffice to carry the large current required for all the lamps. Such a wire would get very hot, and more steam power might be used in heating the main conductors than in causing the lamps to shine. It is easy to calculate what size of conductor would be the most economical. I have here two great rods, each a foot in diameter, and this is the size required to supply a district with 100,000 lamps in the most economical way if the conductors were made of the best material, which is pure copper. You can see at a glance that the cost of some miles of such conductors would be prohibitive.

The great difficulty of an engineering character which was encountered in the early attempts to introduce central station electric lighting lay in the enormous cost of the copper conductors required to carry the current. This, as much as the Electric Lighting Act of 1882, was the cause of the abandonment of all the earlier schemes.

If we do not lay down thick conductors we suffer in two ways. First, the electric pressure is used up in the mains to such an extent that different consumers along the route of the mains do not get the same electric pressure, and the pressure at each house varies with the amount of light being used in other houses.

Secondly, there is a great loss of energy in forcing the current through the thin mains. By thickening the mains we increase our capital expenditure, but we reduce the annual waste of energy in the mains, and it is easy for the engineer to determine the most economical arrangement.

On doing this it was found that the cost was prohibitory for supplying large districts. Deeply interested as engineers were in the progress of electric lighting, no engineer of eminence supported these early and crude schemes

The plan originally proposed was to lay positive and negative mains all over the streets, and to connect the lamps singly or in groups to these mains by wires. This can only be done economically in small establishments where the greatest distance of a lamp from the machine along the route of the conductors is little more than 200 yards. It is excellent for clubs, hotels, and country houses.

If we connect each pair of our lamps in series, so that the same current passes through both, the electric pressure must be doubled but the current is halved, and at once we have a reduction in the size required for the mains. The disadvantage of this is that if one of the lamps of a pair goes out or is put out, the other lamp of the pair also goes out, as you see when I try the experiment. Here are twelve lamps arranged in six pairs, and when I extinguish one of a pair the other goes out. Now, if I connect together by another wire all the wires connecting the pairs, you will see that when I extinguish one lamp there is still a course open for the current, and no other lamp goes out. I extinguish three lamps of three pairs, and still no other lamp goes out. But you do notice that the three top lamps are fed by the same amount of current as the six bottom ones, and are so much brighter. This is a serious disadvantage, but can be remedied by leading the middle connecting wire, which I just now introduced, to the middle of the battery or other source of electric energy which I am using. Now you see there is no difference in the brightness of the light, however many I may extinguish. This way of using three wires introduces a considerable economy in conductors, and extends the distance to which we can work economically to a quarter of a mile, as has been found from numerous trials, especially in America. This is generally called the three-wire system. This, however, still leaves us a long distance from central station lighting on a large scale.

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lutions of the vane, and this number is absolutely proportional to the quantity of electric current which has passed through the coil, whether rapidly or slowly.

VI.—Conclusion.

In conclusion, let me say a few words on the progress of central station electric lighting. In this country it has been slow, owing largely to the Electric Lighting Act of 1882. If electricity be put on the same terms as gas, and if you have your station on a river bank or any place where coal and water are cheap, you can be well supplied with electric light at the same price as gas at 3s. per thousand feet, with a fair profit to the undertakers. On the continent of Europe there are numerous central stations, mostly small, some supplying 30,000 lights. In America the progress has been enormous. Arc lights in series are used largely for street lighting and for shops, and central stations for glow lamps have been plentifully started on the parallel, three-wire, and induction systems. Most of the best companies concerned pay good dividends. The total money invested in electric lighting in the United States is estimated this year to amount to £30,000,000. In 1886 there were 58 Edison central stations supplying 149,900 lamps, besides 181,463 lamps in isolated plants. The Westinghouse Company has during this year been setting up central stations at the rate of 12,000 lamps per month. It is estimated that in 1885 the Brush Company alone had 96,000 arc lamps in use in the States, the number having doubled in each year from 1881. At present there are probably 300,000 arc lamps in use in that country.

The Americans are also getting the start of us in electric railways. We once beat the whole world in steam railways. Our pre-eminence in steam has gone far to make this country what it is. So let it be with electricity, for we are now passing into the Age of Electricity.

REPORT OF COMMITTEE ON ELECTRICAL DISTRIBUTION BY ALTERNATING CURRENTS.*

BY MR. SLATTERY.

One short year ago the commercial success of the branch of electric lighting in which induction coils are used was by some of our best authorities considered very problematical, but practical use of the induction system has not only succeeded in commercially converting high-tension electricity to low tension for electric lighting purposes, but also high-tension theoretical opponents by practical demonstration of facts.

Upon the occasion of the last Convention the extensive use of the induction system received its first authoritative endorsement by our esteemed friend, Dr. Otto Moses, and although he was by some considered over enthusiastic in his statements, time has served to prove the correctness of his views and the realisation of many of his anticipations.

We will go back six months, and mentally what do we see in this business from here? A few experimental plants scattered about in various parts of the country, struggling for public recognition and with the innumerable detail difficulties which dog the footsteps of every new departure, difficulties the magnitude of which are usually in proportion to our ignorance of their nature, and therefore more frequently than not unduly magnified.

Now what have these difficulties been, and has the past six months' experience enabled the manufacturing companies engaged in this branch of business to eliminate them? We find there were three factors in the induction system that required all the ability of the electrical engineer to work out and place upon a proper footing, namely the dynamo machine, the induction coil, and the disposition of the external circuit to take the best advantage of the use of the induction coil. Of course there were alternating dynamos in existence, as were also induction coils, before this lighting branch of business had acquired any prominence, but they were not such as would meet the new requirements.

We will first take the dynamo. It will be familiar to all of you that no matter how intimately acquainted you may be with the construction of a dynamo machine when you start to build a new type, your previous experience, however valuable it may be, does not enable you to foresee innumerable detailed difficulties which will assuredly develop with practical use, and which take time to ascertain and remedy.

Well, so far as we have been able to learn, the weaknesses which developed in this apparatus were, first, the liability of the current to jump across the coils in the event of the field being excited with the armature circuit open. This open circuit sometimes happened by a dead cross occurring at some place in the mains blowing the fuse at the dynamo, thus opening the circuit, and then the field being fully excited the armature would generate an exceedingly high electromotive force for an instant; the current under the circumstances would be very liable to jump across the coils of the armature, and other hurtful effects to the machine would ensue. The remedy for that was inserting at every branch in the external circuit a junction fuse, and at various points along the main and sub-mains section fuses to such an extent as to make an open main a remote contingency. It was also found that the armatures heated excessively, owing to the presence of the plaguy Foucault currents; it was found that this evil could be almost wholly suppressed by building the armature without iron, and avoiding as much as possible the use of masses of metal in proximity with the armature coils. In this connection Siemens' early type of alternating dynamo, slightly modified to meet the new requirements, might read us a lesson.

It was a bold step when the alternating dynamos were constructed with iron cores, and those who make this class of machine for this high-tension incandescent business might give us some interesting information. To my mind this iron core construction speaks of disagreeably high temperature. I do not say that they will not be able to present a rational theory why this evil may not be or has not been greatly modified; but the fact existed in the past, and as far as we have been able to ascertain stands unrefuted at present. One thing, however, is pretty evident, that just now this type of machine appears to be finding a rather extensive use, evidencing that it must be doing good work. So much for the alternating current dynamo, a machine destined to play a most important part in the future electric lighting business, and in the light of the past experience no doubt should exist in the minds of anyone here that these dynamos in practical use are now almost, if not quite, as reliable as any other dynamo, while coupled with this is the important factor of a pretty close self-regulating property attainable in this system, without the necessity for any particular method of winding—that property, following chiefly as the result of the use of the induction coils. It is satisfactory to know that during the probation of this system every accident of any importance which has occurred to the dynamos has been of a purely mechanical nature, and our mechanics have reduced them to a minimum.

No doubt the induction coils have been a source of considerable anxiety, not because there was any obstacle in the way of obtaining high electrical efficiency, this latter appears not to have been by any means a difficult problem to solve; the source of greatest trouble has been, as far as I can learn, that of insulation. In what form will the weakness appear? has been the question often asked himself by a timid electrician, and as usual the most unlooked-for troubles developed. At one time an unaccountable defect in the insulation of the secondary coil would occur, cutting out a number of convolutions, thereby causing annoyance by reducing the incandescence of the lamps in its circuit. The remedy was simple—increase the insulation of the wire and exercise still greater care. The same accident would still more frequently happen to the primary coil; the same remedy applied overcame it. Sometimes a number of the layers of the primary coil would thus be suddenly cut out, resulting in the passage of a much heavier current than the fuse in the coil box had carrying capacity for; the fuse would then melt and possibly draw an arc that you had a great deal rather do without if you could. The remedy for that was, keep on insulating the primary coil layers from each other until the trouble ceased, and increase the distance between the ends of the primary fuse to such an extent that when the latter melted, an arc, no matter how great its volume, would not be able to bridge over the distance, which after all was calculable because the E.M.F. was constant. Then, again, metallic contact would take place between the induction coil and the iron box in which it was mounted, and if that box happened to be placed anywhere near a ground, possibly unpleasant electrical experiences might be related in wet weather. It was again only a question of looking out for the insulation to reduce such defects to a minimum. The insulation appears to have been looked out for, as the smooth and safe working of that branch of the business would now seem to testify, and to-day that part of the system can be made as reliable, simple and as easily disposed of as any other part of an incandescent system.

Thus the two new and troublesome factors have gradually and surely been strengthened for their future work.

The next in the system, viz., that method of distribution which would enable you to utilise the induction coil to the best advantage, although apparently presenting the simplest problems at the outset, has required a great deal more thought than was anticipated. It was found that no particular rule, as in the case of low-tension distribution, could be carried out, the methods of distribution varying with the condition of the district in which you had to distribute.

In some cases the wires were run out from the central station through the centre of distribution, and tapped at any point along the route where lights were required. This was the earliest and simplest form of distribution, and answers perfectly well for comparatively small installations, it being desirable to keep the loss in the mains down to about 2 per cent. and perhaps about 2 to 3 per cent. in the induction coils, so that the incandescence of the lamps should not vary appreciably throughout the system. This arrangement of the circuit may be carried out in small and very scattered towns, where it has been found to answer admirably. In other cases, where the district is more densely populated and a large installation is required, the inductoriums are placed in the centres of distribution and used like so many stationary dynamos, the light tension primary current with comparatively small conductors feeding each of these centres, the secondary or distributing circuit being taken where lights are required. Still, other methods of distribution are carried out, but what has been stated in this connection will serve to show that again the past year's familiarity with the business has given an opportunity to perceive and profit by many advantages the system offers.

One of the last but by no means the least points that I shall touch upon in this interesting subject is the question of comparative cost of the main conductors required in an installation of an induction and low-tension incandescent plant. Not at all unfrequently we shall find ourselves called upon to figure upon a plant like this.

From the source of generation to the point of distribution is one mile and a half, making a three-mile circuit; at the point of distribution you are required to distribute some 400 16 candle-power lamps at, say, 5 per cent. fall of potential, which appears to be about the limit allowed the induction system. The necessary conductors for this purpose in the induction systems now in use would be No. 2 Brown and Sharp, which will cost about $250. In the case of the installations upon the low-tension system you would require a conductor costing about $1,050.

Should you be required to distribute throughout the whole of the length of the circuit, the wire such as is used for ordinary arc lighting purposes would be amply sufficient for the induction, and of course a proportional reduction may be made in the low tension.

Now, a great many exaggerated statements are made with regard to the

* Paper read before the American National Electric Light Association.

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dangerous shocks to be expected from this alternating current, and while I am not prepared to say that the physiological experience of a shock from a thousand-volt dynamo is the most agreeable thing in the world, I am prepared to say that the shock is by no means so severe as that received from a continuous current dynamo of the same voltage. A few weeks ago a man showed me his hands, which were horribly burned. He had received a shock from an eleven hundred-volt dynamo, and he said, with a visible tremor in his arms as if the recollection of that shock was still vividly impressed upon his mind, that he experienced the effect of that shock for more than a week afterwards. A friend of mine was testing a 400-light 1,050-volt alternating dynamo, fully loaded, only a few days ago, and going towards the machine his foot slipped and he fell quite close to it; in his confusion he quickly reached out his hands and unfortunately placed them directly upon the poles of the dynamo. He said from where he fell to the walls behind him was about fifteen feet, and it seemed to him as if that dynamo was suddenly converted into an electrical gun, and he got shot across the room until the velocity of his movement was interfered with by the wall. There was scarcely the appearance of a burn on his hands, merely a pin's head matter, while the effect of the shock was felt by him only for a few hours. It might be said that the difference of the effect of the shock was owing to the difference in the temperament of the two men; that may be so, but I have received three pretty severe shocks from a 1,000-volt alternating machine, and, however much I may have felt inclined to dispense with the shaking up it gave me, the experience was of value to me—one cannot have everything.

One word more in conclusion. The induction system has evidently come to stay, not because enthusiastic advocates think or say so, but because the expert public, the central station public, have practically endorsed it, because it more nearly than anything else meets their immediate, and anticipates many of their future, requirements. More especially is its advent doubly welcomed just now with this misconducted overhead conductor warfare pressing on every side, and which is every day acquiring seriousness in proportion to the increase of copper wire in the air, and I think that this system with its comparatively small mass of conductors, will postpone for a considerable time the necessity of going underground with the electric light wires until more extended experiments shall have given us the confidence in underground systems that experience in the past has materially shaken.

Mr. SMITH, of Alleghany City: Mr. Chairman—I would say that I have had some experience with the alternating system with which Mr. Duncan is connected, and also with another company in Philadelphia, where we started with the direct system first and then changed it to the alternating. There are some points on which Mr. Slattery has asked questions, and I think that on some of them I may be able to assist him. We have found that when you are using a converter system, it enables you to employ almost any system of distribution you want. In Pittsburg, where we were running lights in a rather poor neighbourhood, we found it cheaper to run secondary mains, attaching our lights in the houses from the secondary current, using fifty or one hundred volts as we pleased. In other parts of the town, where they were using fifteen or twenty lights in each house, we found it better to carry the converters into the building, or fasten them as close as possible on the outside wall, so as to enable us to use the fifty-volt lamps exclusively. In the case of hotels we would run a high-pressure wire down the centre of the corridor, and place converters at each group. In Philadelphia, where we had a direct current, and wanted to change to an alternating current, we changed without the slightest trouble three or four hundred lights from one system to the other without shutting off the light for a moment. Whenever we wished to change a section we would cut the section at that point, put in converters, and then splice up again.

In regard to the question of heating up the machines that Mr. Slattery speaks of, I would say that on the newer machines we run them for a week, starting them Sunday afternoon and stopping them Sunday morning. During all that time the machine never gets so hot that you cannot bear your hand on it, a fact which shows that the working of the machine is not very much interfered with. In the larger machines—the 1,300-light machines—we have one there that has been running about two months, stopping only about ten minutes per day, and if the engineer does not feel disposed to, he does not stop it then. We never had the slightest trouble in the way of heating. You can always bear your hand on it.

The converters I know absolutely nothing about. I put them in and that is the end of it. I think we have had to take out two during four months.

Mr. W. R. KIMBALL, of Boston: In regard to the alternating system for supplying incandescent lights, there has been a marked advance since the last Convention in Philadelphia. From the various installations which are at present in operation we have been able to get data which are not only interesting but useful. The question of the insulation of high potential wires is one which appeals to every part of the electric light station, whether he be line man or manager. In the one case it is his own life and limb that are involved, and in the other case it is property. And yet there is danger in carrying high-potential wires into cellars and basements.

There are very many cases where it is convenient and economical, in cities where we are not allowed to put the wires on poles, instead of putting the converter high up on a fixture—it is very inconvenient to put a converter of one hundred lights on the top of a man's building—to carry a *o* or *oo* wire down into the building, if a way can be devised to carry safely the currents which approach at least the intensity of arc currents into cellars and basements, and handle the apparatus without that sense of danger which is now felt. That is a thing that is needed at present.

The question of the insulation between the primary and the secondary of the inductive coil is governed by a variety of causes. Where converters are placed out of doors moisture will get in. No matter how carefully the wires may be placed the current will be affected. This bold expedient of grounding the inside wire has been brought to the attention of this Convention and the public by some of the electrical papers. It seems to me that it opens a field for discussion. The question naturally arises in the minds of insurance men whether running electrical wires down to the ground is not an unheard of thing. The fact must be considered that there is a plan for the complete isolation of this wire from any other wire in the town or city. It is not to be compared with the grounding of a positive wire in a system of distribution where seventy-five or one hundred volts are distributed.

In regard to distribution over a large area, in discussing incandescent lights, it seems to me that those of us who have the practical work to do are apt to lose sight of the fact that all the laws of wiring and construction work which apply to the low-tension wiring are equally applicable to the alternating system, and all the appliances made for straight incandescent work may be utilised for the alternating current by conforming to the laws now so well known regarding self-induction. And it is a question to be decided by the electric light engineers in practice to determine whether it is better to rely on the high-potential wires for a system of distribution and lay them with as much care as the low-potential systems, and place converters as near the lamps as possible, anywhere they may be required, or whether it is better to run a plainer system of high-potential mains and rely on inside wiring. By inside wiring I mean this: In many plants the converters are placed in groups connected by a main trunk secondary, which is practically the same as the mains in a system of distribution, so that part of the advantages of an alternating system are lost.

Mr. SMITH, of Alleghany City: I do not represent the Westinghouse people, but I have had exceptional opportunities for examining their work. In Philadelphia we are using their work. We have satisfied ourselves that if we can get a good metallic covering it is about as good as anything that is to be had. The outside covering of the cable was not insulated in any way from the iron junction box, though the wire carrying out current was. In some parts of the streets we found it difficult to lay the wooden boxes, and we used iron pipes through which we pulled the cables and filled the pipes with pitch to prevent the average Irishman from driving his pick through them. We have not had the slightest trouble from loss of current or anything else, and our men handle those cables with perfect impunity. I understood that some experiments had been made by the Westinghouse Company with regard to insulation. I made some inquiries of them, and their answer was that we could use any kind of cable that we wanted as long as the covering was good; but for practical reasons they should recommend to us in this particular instance a lead covered cable, having both conductors in one lead covering. That is to say, two separate cables soldered together through their whole length. They made the test for me. They tested a quantity of cable thoroughly, and they told me that I would get perfect satisfaction out of it. The question was raised as to whether our men would not be liable to get shocks from the covering of the converters if they were not grounded. We tried it and found no effect whatever. I have had no experience with a long conduit of iron. Ours have always been short. It seems to me that any effect of the positive would be neutralised by the negative at any one instant.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 9th, 16th, and 23rd inst. amounted to £3,057, £2,477, and £2,873 respectively.

EASTERN TELEGRAPH COMPANY.—This company announce the payment on the 14th October next of a dividend of 3s. per share on the preference shares of the company, less income-tax, for the quarter ending 30th September, and an interim dividend of 2s. 6d. per share on the ordinary shares of the company, free of income-tax, in respect of profits for the quarter ended 30th June. The register of transfers will be closed from the 7th to 14th October, both days inclusive.

EASTERN EXTENSION TELEGRAPH COMPANY.—This company gives notice that the accounts for the half-year ended 30th June last show, subject to audit, a balance of profit of £66,655, after the payment of the interim dividend for the first quarter. The directors, on 28th inst., declared a dividend for the quarter ended 30th June of 2s. 6d. per share, free of income-tax, payable on October 15, and decided to carry the balance of £35,405 forward to the next account.

NEW TELEPHONE COMPANY.—According to a circular which has been forwarded to us, this company has completed new arrangements for manufacturing, and states that it is supplying an instrument of an entirey new design. The address of the company is 4, Great Winchester-street, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the three weeks ended September 23rd, were £2,406, £1,373, and £1,578 respectively, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

PERSONAL.—It has already been announced that Mr. Trotter, late partner in the firm of Goolden and Trotter, has left that firm. The partnership, we believe, has been dissolved by mutual consent, and Mr. Trotter will shortly return to London and be practically engaged in some branch of engineering. The existing business will be carried on by Mr. Goolden, under the title of W. T. Goolden and Co., and the firm will continue to work Mr. Trotter's patents, and conduct the factory which has hitherto been under his management. We have it on the best authority that Mr. Trotter wishes the firm all future prosperity. There is no doubt that the present position of the firm owes a

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good deal to the energy and the ability of Mr. Trotter. He has designed and constructed dynamos and other apparatus which have commanded a considerable amount of business success, and there is no reason why, under the future management, they should not continue to do so.

BANKRUPTCY.—Oswald Ricketts Swete, of 108, Barons Court-road, West Kensington, and Albion Works, 141, Kensal-road, Westbourne Park, and 11, Victoria-street, London, lately trading in co-partnership with William Charles Main, as electric light contractors and engineers, under the firm of Swete and Main. The first meeting of creditors will be held on the 4th of October at 11 o'clock. It may perhaps be interesting to add one of the observations upon this bankruptcy. The debtor states that he began business in October, 1885, with borrowed money, £300 (included in unsecured creditors), and in March, 1886, took into partnership Mr. Wm. Chas. Main, who introduced £330 capital; that such partnership was dissolved in March, 1887, Mr. Main retiring and the debtor taking over the liabilities and assets of the firm, and agreeing also to pay a sum of £436 by instalments, of which a balance of £432. 8s. 6d. remains due. This partner is included among the unsecured creditors, but his claim appears to be one that must be postponed until the remaining debts are satisfied.

COMPANIES' SHARE LIST.

TELEPHONES.

Companies.	Closing Prices. Sept. 28.		Business Done Week Ending Sept. 28. Highest.		Lowest.	
Consolid. Telephone and Maintenance..	11-16	13-16	.....	—	.....	—
Oriental	5-16	7-16	.....	—	.....	—
United Telephone	12,	12½	.....	12½	.....	—
United River Plate	4⅞,	5½	.....	5	.....	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)..	1¼,	1⅝	.....	1½	.....	—
Do. (fully paid)	3.	4	.....	—	.....	—
Swan.....	1½,	1⅞	.....	1⅝	.....	—
Maxim Weston	3-16,	5-16	.....	¼	.....	—

MISCELLANEOUS.

Telegraph Construction	37,	38	.....	37½	.....	37
India Rubber, Gutta Percha, and Telegraph Works	21,	22	.....	22⅜	.....	21½

TELEGRAPHS.

Companies.	Closing Prices. Sept. 28.		Business Done Week Ending Sept. 28. Highest.		Lowest.	
Anglo-American	36½,	37½	.....	36½	.....	36
Do. Preferred	60.	61	.....	61	.....	58½
Do. Deferred	14¼,	14⅝	.....	14¼	.....	13⅞
Brazilian Submarine	11.	11¼	.....	11 3-16	.....	11
Cuba	11⅞,	12¼	.....	12⅛	.....	11 9-16
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅞,	3¼	.....	—	.....	—
Do. Preference	7⅞,	8½	.....	—	.....	—
Direct United States Cable	8¾,	9	.....	9	.....	8 13-16
Eastern Telegraph	11,	11¼	.....	11¼	.....	10 15-16
Do. 6 per Cent. Preference.....	14,	14½	.....	14½	.....	14
Do. 5 per Cent. Debentures, 1899 ..	106,	109	.....	—	.....	—
Eastern Extension	11⅜,	11⅝	.....	11⅜	.....	11⅜
German Union	10½,	11	.....	11	.....	—
Globe Telegraph and Trust	5⅛,	5⅜	.....	5 9-16	.....	5⅜
Do. Preference	13¼,	13⅜	.....	13⅜	.....	13 3-16
Great Northern	13½,	14	.....	14	.....	13⅜
Indo-European	36.	38	.....	37½	.....	—
Reuter's	7⅞,	8½	.....	8½	.....	8
Submarine	170.	180	.....	—	.....	—
West India and Panama	⅝,	¾	.....	—	.....	—
Do. 1st Preference.....	9⅛,	9⅜	.....	9⅜	.....	9⅛
Western Brazilian	7¼,	8	.....	—	.....	—
Western Union 7 per Cent. 1st Mortgage	120.	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds.....	101,	104	.....	103	.....	101

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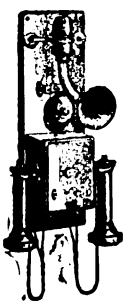

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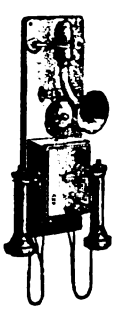

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NOTES.

FOREMAN OF TELEGRAPH WORKS REQUIRED.—The attention of those interested is directed to an advertisement by the Government of the Gold Coast to the above effect which will be found in another column.

BRIGHTON.—It is expected that telephone communication between Brighton and Lewes will be opened early next month. The difficulties of finding a route between Lewes and Eastbourne have now been surmounted, and this additional length of wire will soon be ready for use.

"WHAT IS ELECTRICITY?"—In another column will be found an interesting letter under the above heading from Mr. Townsend Wolcott. The original paper referred to will be found in our issue of July 15th, and our remarks thereon were given amongst the "Notes" of the same date.

THE LIGHTING OF THE CITY OF LONDON.—At the meeting of the Commissioners of Sewers, held on Tuesday last, Mr. J. C. Bell, in reply to Mr. Morris, said that he had no objection to state that, on the report of the engineer, Mr. W. Haywood, C.E., the Streets Committee intended to proceed with the lighting of Queen Victoria-street and Cannon-street by the electric light.

INSUFFICIENT TELEGRAPH ACCOMMODATION IN THE METROPOLITAN AREA.—The inhabitants of Plumstead consider that they have good ground for complaint in the fact that with a population of 40,000 there is only one telegraph office in the whole district. The inhabitants of New Eltham are, however, in a worse case. Here there is a population of over 10,000 without any telegraph accommodation whatever.

BANK OF ENGLAND.—We understand that the Bank of England have determined to put down two additional dynamos and a new engine for the purpose of lighting most of the remaining rooms and courts. The installation is being carried out under the supervision of Messrs. Drake and Gorham, and is, we understand, to be ready for running within the next two months. The installation at the Bank of England is one of the earliest in which accumulators were employed with continuous success.

THE "WATT" DYNAMO.—Our readers will have observed that a paragraph has been going the rounds of the daily press describing a new type of dynamo machine "invented by Mr. Hugh Watt, M.P.," of the Maxim-Weston Electric Lighting Company. We shall defer a description of this interesting machine, at least for the time being, but we must not omit to mention, on the authority of one of the paragraphs in circulation, that "it works at 1,000 revolutions per minute, is driven by a 14 horse-power engine, and gives 130 *ampere hours* (!) at 65 volts."

ELECTRIC LIGHT IN THE GERMAN ARMY.—A daily paper states that the German artillery has recently been carrying on a series of successful experiments in lighting forts with electricity, with a view to facilitate a bombardment at night. On the practising grounds, near Jüterbog, 36 guns of all calibres recently fired off 2,500 shrapnels and other missiles under the electric light, the distance being from 2,800 to 3,800 metres. The experiments took place in the presence of about 80 officers, including six generals. Though the night was very dark, the effect of every ball could be clearly seen.

PROTECTION OF LIGHTNING CONDUCTORS.—The *Illustrirte Zeitung für Blechindustrie* recommends the following method of protecting the copper wires of lightning conductors on factory chimneys from being affected by gases. The wires exposed should be provided with an insulating covering of india rubber, over which a protective composition should be applied of the thickness of 2-5ths of an inch. The latter is prepared by mixing ground fire-brick with finely chopped straw and clay-water into a moderate thick paste. After the composition has dried, asbestos string should be wound round it so as to prevent its crumbling away.

EDINBURGH.—Some curiosity was excited in Edinburgh on Saturday evening last by the appearance of a light of unusual character which moved slowly to and fro at a great height above Castle Hill. The explanation of the matter was that an experiment was being made with a captive balloon above the Observatory. Half-a-dozen incandescent lamps of twenty candle-power, each protected by a wire cage, were placed in the interior of the balloon, and were connected with the dynamo in the building below by means of two insulated wires. The effect was rather spoiled by a mist which hung over the city at the time. Experiments were also made in signalling by the Morse system.

THE WEST AFRICAN TELEGRAPH COMPANY.—The staff of the West African Telegraph Company (Limited) addressed the following message from São Thomé to Her Majesty upon the occasion of her Jubilee, June 20th:—"Your Majesty's most loyal subjects, the employés of the West African Telegraph Company, resident on the West Coast of Africa, desire your Most Excellent Majesty's happiness on this Jubilee day, and health and strength to long continue your Majesty's prosperous reign." The following reply was received:—"London, 22nd, 12:10 p.m. Employés, West African Telegraph Company: Queen thanks you and your comrades for loyal congratulations. —Private Secretary."

THE TELEPHONE IN CHINA.—Mr. Morgan, of the American Bell Telephone Company, contradicts the absurd rumour that proceedings had been taken to prevent the introduction of the Bell telephone in China. What has been done is merely in view of taking steps to prevent the manufacture of the instruments in America by unauthorised persons on behalf of the Philadelphia syndicate. It is obvious that unless the promoters of the new scheme have possession of an instrument beyond the scope of the Bell patent they must either purchase their instruments of one of the Bell companies, or they will have to manufacture in China or elsewhere, beyond the limits of the patent.

THE USE OF THE MAGNET IN THE MANUFACTURE OF PAPER.—During the manufacture of paper, as soon as the pulping machines exhibit signs of wear it is not uncommon for a good deal of paper to be spoilt by the abrasion of minute specks of iron which fall into the pulp and afterwards produce rust stains. Occasionally the stains do not appear until the paper has been damped for printing, and a good deal of annoyance is thus caused. The *Papier Zeitung* announces that this difficulty may be overcome by the use of magnets in a very simple and effectual manner. A kind of steel comb with broad teeth set edgewise is placed in the stream of pulp and water which issues from the machine. The teeth are made of magnetised steel strips, and any iron particles contained in the pulp are thus withdrawn.

THE FRENCH TELEGRAPHS AND THE RECENT MOBILISATION.—Our contemporary, *Electricité*, has some rather disparaging remarks concerning the use made of the telegraph during the recent mobilisation of a French army corps. The

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telegraphists upon whom would devolve such important duties on the outbreak of war were not, in the opinion of our contemporary, sufficiently put to the proof during the mobilisation; the authorities were too easily contented to rely upon lines which already existed between the chief places in the district. Only one special line was put up; this extended from the railway at Carcassonne to the waggon depot at Estagnal. Communication with Paris was maintained by means of two lines from Castelnaudary, upon which Hughes's type-writers were employed, and the only measure of additional precaution it was deemed necessary to take appears to have consisted in the despatch of one spare instrument to Castelnaudary.

THE TELEPHONE IN AUSTRIA.—Austria is at the present time decidedly behindhand in the matter of telephonic communication. There are only 12 exchanges with 3,000 subscribers, of which 1,000 are in Vienna. The tariffs are very moderate. At Vienna the subscription amounts to 300fr. per annum up to a distance of two kilometres from the central exchange, with an addition of 60fr. per kilometre beyond this distance. At Brünn, Prague, and Trieste the charge is only 180fr. within a radius of two kilometres, and in the remaining towns it varies from 120 to 160fr. per annum, with an additional 40fr. per kilometre beyond the first two kilometres. The Austrian Government has recently opened an exchange of their own at Reichvau, a manufacturing town in Bohemia, and it is said that the results have been so satisfactory that they are now preparing to introduce the service in several other towns, amongst which are named Salzbourg, Cracow, and Klagenfart.

THE OLD STUDENTS' ASSOCIATION OF FINSBURY TECHNICAL COLLEGE.—The third annual dinner of the City and Guilds of London Finsbury Technical College Old Students' Association, was held at the Holborn Restaurant, on Friday, 29th ult. The chair was taken at seven o'clock by the president, Mr. Alfred Chatterton, B.Sc. Among the numerous guests were Profs. Ayrton and Armstrong, of the Central Institution, Profs. Thompson and Perry, of the Finsbury Technical College, Messrs. Blaine, M.E., Millis, J. H. Chatterton, and others. After dinner the principal toasts were "The College," proposed by the chairman and responded to by Prof. Silvanus Thompson; the "Central Institution," proposed by Mr. H. N. Lawrence and responded to by Prof. Ayrton; and the "Old Students' Association," proposed by Prof. Perry and responded to by the chairman as president of the association, and Mr. W. F. Pettigrew, as president-elect. With the above speakers, and an agreeable selection of music, an extremely interesting and enjoyable evening was spent.

THE LIGHTING OF THE OLYMPIA HALL.—We are informed that an addition is to be made to the number of arc lamps in the Olympia Hall at Kensington, in view of the return of the Paris Hippodrome in a few weeks' time. At present the electric light plant consists of some 60 Brush arc lamps and about 350 incandescent lamps. These are to be supplemented by 64 arcs, taking 10 amperes each. It appears that an immense quantity of light is required in the ring, as there are, in addition to the electric light, 10 large gas coronas, giving about 2,000 candle-power each, arranged in two rows over the arena. There is ample dynamo and engine power for the new lamps, which will be connected in parallel circuit, and arranged so as to be, in common with all the rest of the lighting, interchangeable on any of the machines. The work will be carried out by Mr. Arthur Carey, engineer to the Hall Company. The services of Mr. Guy C. Fricker, who has lately commenced practice as a consulting electrical engineer, are also engaged on the work.

THE BONTA (SO-CALLED) MAKE-AND-BREAK TELEPHONE TRANSMITTER.—In our issue of September 2nd we described a telephone transmitter recently brought out in America, in which a carbon ball rests against a carbon point, and is capable of a to-and-fro motion. By the aid of photography it was claimed to have been demonstrated that during the process of transmitting speech the ball was at times separated from the carbon point by a clear space, and on the strength of this demonstration it has been claimed that the instrument does not produce an undulatory current, and is thus clear of existing patents. We pointed out at the time that the conclusion set forth is not justified by the premises, unless it is also shown that the circuit is entirely devoid of self-induction. But, further than this, Mr. W. C. Barney, writing to a contemporary, now describes some observations of his own made upon this instrument, which is now being publicly exhibited in New York. He states that the receiver employed was an ordinary Bell, and that while the transmission was perfect while speaking in a low tone of voice, yet if louder tones were employed the instrument became absolutely dumb. From this it is perfectly clear that as soon as the degree of make-and-break exceeds the interval corresponding to the time constant of the circuit—that is, as soon as the current ceases to be undulatory—articulate speech ceases to be transmitted. It would be difficult to devise a better proof of the practical necessity of undulatory currents.

THE SUCCESS OF UNDERGROUND CONDUITS AT CHICAGO. Prof. J. B. Barrett, electrician to the City of Chicago, is justly entitled to the credit of having been the first to grapple successfully upon the large scale with the problem of underground conduits for electric wires of all descriptions. In a recent paper with the alluring title "How to Obviate the Danger Emanating from Overhead Electric Wires," Prof. Barrett said:—"We hear every day from somebody, away off down in some swamp or back alley, shouting at the top of his voice, 'Underground is a failure; it don't work!' And yet all the time it is working in Chicago; and in our conduits we have as many varieties of wires as there are above ground in any two cities of the Union—as many kinds, understand. We have everything, from a cable less than an inch in diameter, with fifty wires in it, up to a cable as big as your thumb, and only one wire in it; we have telegraph and fire alarm, and telephone and call bells, watch service, mercurial and burglar alarms, and police and—well, if you can think of anything else, call the turn; we've got it in our conduits, and they all work, and work far more satisfactorily than the overhead undertaker lines. Do not let the croakers rule you off the track." This is, of course, very satisfactory, but it must always be remembered that the overhead wire problem in the American cities is a very different thing from what we are accustomed to in this country. Instead of having to deal merely with telegraph and telephone wires, the American citizens are confronted at every turn with heavy cables conveying high tension arc lighting currents, or consisting of bundles of 50 or 100 telephone wires.

METHOD OF OBSERVING THE ACTION OF MAGNETS ON LIQUIDS.—Mr. S. T. Morehead, writing in Silliman's *American Journal* for September, describes a novel method of observing the action of magnets on liquids. He says:—"Some weeks ago one of my students, Mr. J. C. Child, and myself were working with a diamagnetic instrument, simply repeating well-known experiments. Plücker's method of observing the diamagnetism of liquids having failed in our hands to give satis-

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factory results, we hit upon a method which was new to us and which was very satisfactory. Into a glass tube of about four or five millimetres internal diameter a small quantity of liquid was introduced forming a short cylinder. This tube was placed horizontally at right angles to the line joining the poles of the magnet, with the liquid nearly between the poles. When the current was turned on, the liquid was very evidently repelled. Water was repelled through a distance of about half a centimetre; wood spirit through a greater distance. By moving the tube in the direction of its length the wood spirit could be pushed any distance through the tube. The amount of motion is of course a function of the resistances due to adhesion and friction as well as of the repulsive force. The attraction of liquids is easily shown by the same method. A single modification of the above plan of proceeding is to incline the tube slightly so as to make the liquid flow toward the poles. If the acquired velocity be not too great the magnet acts as a break to stop the motion. It is well to bend the tube up a little at each end to prevent the liquids from flowing out. This method is well adapted for projection so as to be seen by large audiences."

Secondary Batteries at Brooklyn in 1871.—A few weeks ago Captain Henry Oceanus Cook met with a fatal accident by being run over and killed upon a railway near New York. The name of this remarkable man has not hitherto been familiar to ourselves, but if the following account, which appeared in one of the New York daily journals, contains any element of truth it would be interesting and even important to learn something more of his achievements. The journal in question, plunging at once *in medias res*, says:—"In 1864 he resigned his commission as Lieutenant-Commander in the Indian Navy and came to the United States, where he has ever since resided. At Portland, Me., he established a manufactory of electric appliances. He there constructed the first electric marine engine, and applied it to the propelling of a boat. But he had hardly become well established here when the great fire of 1866 destroyed every vestige of his work. He then established a factory at Boston. Here he designed and invented a trans-isthmian marine railway, and also a bicycle, but his applications for patents were rejected. He also invented a neutral marine compass, and his success was promising, when fire, in 1868, again destroyed his factory. The next year Capt. Cook came to New York. He invented an electric storage battery in 1871, and successfully applied it to the running of a street car in Brooklyn. In 1872 he invented a pocket electric lamp. He is said to have discovered processes by which alcohol was deprived of intoxicating properties and hydro-carbons made perfectly neutral. He also invented a 'broken line' telephone, which, however, had not reached perfection when he was killed. Since 1872 he has been continuously engaged in experiment and investigations in electric machinery and motors."

A Confession.—An American journal relates the following mournful tale:—"Johnny Norton, who a few years ago was well known all over the country as Bunnell's 'electric boy,' is now working in this city as a compositor. In reply to the query of a reporter as to what had become of his electricity he said: 'When I was on exhibition I was enclosed in an oblong stall about seven or eight feet long, the front of which was like a narrow counter. Opposite the counter was a rail which only allowed the visitors to pass in single file. A long strip of cocoa matting served as a carpet for the passageway, and also as a cover for a sheet of zinc which extended beneath it, running the length of the stall. My box was similarly invested with zinc and matting. Attached to the sheets of metal, but hidden from view, were the two poles of a galvanic battery, one under my feet and the other in the passage. Now, anyone passing over the zinc and touching me, behind the counter, completed the circuit and received a shock. So did I. The matting, of course, had to be kept damp, water being the conductor. It was surprising what intelligent people were duped by this trick. Why, I was kept shaking hands and being fingered from morning until night. Many is the $2 note I received from doctors and others for a couple of drops of my blood for analysis. One evening three or four young students came in to unmask me. One of them made a wager that he would electrify the audience the same way if he was in the box. I immediately invited him in and he accepted the challenge. I then retired, but before doing so I pressed a hidden button that cut off my wire. He, of course, failed, and ignominiously retreated, after being guyed unmercifully by those present. This proved me genuine to the satisfaction of every one in that town, and I became famous. There was a lot of fun in the business; but I had to give it up, as the constant strain caused by the battery was too much for me."

Electric Compared with Gas Illumination in Works and Factories.—On the *audi alteram partem* principle we reproduce the following letter, which Mr. H. Leicester Greville has addressed to our contemporary, the *Journal of Gas Lighting*:—"Sir: I read with very great interest the report of Prof. Fleming's able lecture on the above subject which appeared in last week's *Journal* (Sept. 20). The paper is strictly what its title would lead us to suppose—viz., a comparison between gas and electricity as sources of light in works and factories; and whilst not being blind to the advantages of electricity over gas in particular instances, I consider Prof. Fleming's paper scarcely does justice to gas on two particular points. Firstly, stress is laid in one or two instances on the improvement in the condition of the air of workshops consequent on abandoning the use of gas and adopting the electric light. The comment on this by those intimately conversant with gas would, I think, be that with the good ventilating burners in the market, an expenditure far short of an electric light installation would have not only prevented vitiation of air by the gaslights, but have effected, in addition, an amount of ventilation which might have had a more important influence on the health of the workpeople than even the installation of electric lighting. Secondly (and this is perhaps the more important point of the two), there is the question of comparative cost. The only detailed statement on this head in Prof. Fleming's lecture is where particulars are given of what is known as the cheapest form of electric lighting, viz., the arc. The figures are 6¼d. per hour per lamp of 2,000-candle light. It is subsequently stated that this nominal 2,000 candle-power can be taken as 1,000-candle actual, and that to secure the same light from gas, '400 cubic feet per hour would have to be burnt in a good burner, and this at 2s. 6d. per 1,000ft. is 1s.' Now 400 cubic feet of gas to produce a light of 1,000 candles is only an allowance of 2·5 candles per cubic foot of gas burned, when it is a well known fact that such a performance (with 16 candle gas) is worthy only of the commonest and crudest forms of burners. Had the comparison been made with an allowance only of 5 candles light per cubic foot, the cost of the 1,000-candle light becomes only 6d.; and there are regenerative burners in the market claiming a much higher power than this, effecting a proportionate decrease in the quantity of gas to be consumed in order to produce a required amount of light."

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THE ELECTRIC LIGHT AT CADIZ.—The Maritime Exhibition at Cadiz, which the Duke of Edinburgh and the Mediterranean fleet visited some weeks ago, is fully in order. The electric lighting, which was undertaken by R. E. Crompton and Co. on the 24th July, started running on August 25th. The plant consists of three 16 horse-power Marshall's portable engines driving seven Crompton-Bürgin dynamos and three Crompton incandescent machines. These supply forty-two 3,000 candle-power arc lamps and 250 incandescent 16 candle-power lamps. Thirty-two arc lamps are placed in the grounds, and three in the machinery shed. The incandescents are distributed between the large central hall, the picture gallery, a small pavilion put up by the Spanish Steamship Company, and the temporary theatre used for the Italian Opera. Thirty-eight lamps for the stage of this theatre, including wiring, were put up in one day. This is at present the only theatre in Spain lighted by electricity. One 16 horse-power engine with two arc lamps and one incandescent machine are held in reserve in case of accident to the rest of the installation. The arc lamps are run in five circuits, viz., four of nine lamps and one of seven lamps. The Exhibition buildings consist of isolated pavilions of light but extremely elegant construction, the style of architecture being Moorish. The pavilions surround two large squares, which are divided in the centre by the grand hall (500ft. long); from the square, or, rather, crescent on the seaward side of this radiate seven smaller pavilions. These run out over the sea, their foundations being shaped like the bows of a vessel. The effect at night by the brilliant rays of the numerous arc lamps is pretty and fantastic in the extreme. Among the exhibits is a handsome showboard of the various telephones and magnetic bells manufactured by the Consolidated Telephone Construction and Maintenance Company. A considerable number of telephones of the Consolidated Company have been erected in Cadiz and Jerez, and have given every satisfaction. The whole work of the installation of the electric light has been carried out with great success and promptitude by Messrs. R. E. Crompton and Co., under their engineer, Mr. R. F. Hayward. We say this advisedly, because in this case, after the exchange of a few telegrams, one of the principals of the firm went over to Cadiz, and the contract was soon settled, whereas we have known valuable contracts lost on the Continent for want of a little energy and enterprise in London.

WESTON-SUPER-MARE.—The Thomson-Houston plant which has been at work at Weston-super-Mare during the summer has now ceased running, but it is hoped that before long arrangements may be made for its permanent employment. The close of the season was marked by a lecture on electric lighting, delivered by Mr. J. C. Wharton to a crowded audience at the Victoria Hall. The chair was taken by Mr. Wicksteed, who in the course of his remarks said that he had had the electric light in his own drawing room for the past month, and, with all in the house, felt when last Saturday night came that he was saying "good-bye" to a dear friend. He only hoped, however, that it was "*au revoir*" and not "adieu." He looked forward to the immediate future in which the light would be introduced into Weston-super-Mare. It would, he felt convinced, prove of benefit to the poorest and humblest as well as to their more well-to-do fellows; and the more of it that was used the cheaper it would become. Dr. Roxburgh said the electric light had been the feature of the season this year in Weston-super-Mare. He had noticed that the moon was quite put out by it several nights. One had only to walk along the Esplanade in the evening to see how much it was enjoyed by those who assembled there to listen to the music, its only disadvantage seeming to be the appearance it gave to the faces of the persons subjected to its rays. And in the High-street it was quite as much to be appreciated. He (Dr. Roxburgh) had been struck with Mr. Wharton's special pleading in regard to the point as to how gas shares would be affected by the electric light, Mr. Wharton having proved to demonstration that gas shares would largely increase in price as the result of the introduction of the electric light. Having made reference to a Birmingham musical festival at which he was present two years ago, and compared the comfort and vitality experienced at it by the performers and the audience on the nights when the town hall was illuminated with the electric light with the state of things that existed when the building was lighted with gas, the doctor observed that all ought to know that every gas burner used as much oxygen as three people, so that if there were six or eight burners in a dining room they would consume as much oxygen as eighteen or twenty-four persons. It was a demonstrated fact, demonstrated by experience as well as theory, that the electric light was infinitely preferable to gas. The following resolution was carried by acclamation:—"It is the feeling of this meeting that it would be to the interest of Weston-super-Mare, and add greatly to its attractiveness, thereby increasing its prosperity, to light the principal streets and the Esplanade with the Thomson-Houston system of electric lighting. The month's trial of this system has given great satisfaction to visitors and residents."

ABOUT LIGHTNING.—There is an opinion prevalent among the public that lightning does not strike twice in the same place. This, however, is a fallacy, as it is well known to those who study electrical phenomena that lightning does strike in the same place more than once, and that it will fall upon a certain place just as often as the natural conditions are such as to determine the lightning discharge to that point, or just as often as that place lies within and forms the path of least resistance. Probably one of the best illustrations of numerous lightning discharges falling upon one place that has ever been recorded in the United States is upon the farm of Mr. W. F. French, who lives near Flushing, Genesee county, Mich. Mr. French is an industrious farmer, and from the numerous lightning visitations he has had, he might well ask, When and where will it end? In the summer of 1871 his barn was struck by lightning, doing but slight damage to the barn, but killing a fine team of horses, worth $400, which were in the barn at the time. In 1878 the same barn was again struck in exactly the same place, and another fine team, that he had refused $400 for, were killed while standing in the identical stalls occupied by the team that was killed in 1871. In 1884 a fine Clydesdale stallion, valued at $1,000, was struck and killed, and during the present summer he lost another valuable horse, valued at $200, which was struck while grazing in a field. At various times between the above disastrous strokes a great many trees were shattered, and it is a frequent occurrence for lightning to strike the earth in an open field, often tearing a hole in the ground. The great frequency with which lightning strikes upon this farm suggests forcibly that there must be some natural cause for it. The land is rolling, and a small stream meanders through one part of it. The soil varies, and there are several kinds of trees on the place, such as beech, maple, oak, basswood, and ash. Mr. French states that he has found what he supposes to be an iron ore, but that he has never investigated the matter to learn the extent of the body of ore or ascertain its nature. I could cite many cases where lightning has struck several

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times. No doubt many citizens remember the terrible accident at the Atlantic Flour Mills in St. Louis on August 12th, 1881. On the same day just five years later the new mill, now called the Regina Mill, was struck, but the conductors saved the building. The charge was a heavy one, as it wrenched the conductor leading to the earth on the north side loose. In St. Louis lightning falls more frequently in the vicinity of Main and Plum and in the neighbourhood of the Belcher Sugar Refinery than in any other portion of the city. I have noted this fact for the past seven years, and have records of many discharges in those districts, which happily did but slight damage.—*New York Electrical Review.*

JAMAICA.—The history of the connection of Jamaica with the system of submarine cables is given in "The Note Book of Jamaica," just published by Mr. Stanford, of Charing-cross, in which we find that in 1870 the West India and Panama Company obtained the transfer of the rights of the International Ocean Telegraph Company, and thereupon extended to the colony their telegraph system. The new company was aware that the local Government was unable to afford pecuniary support, and it was not till 1876 that they solicited a contribution from the Government approximate to the means of so important a part of the West Indian possessions. In reply, Sir William Grey expressed a hope that the Imperial Government would not be behindhand in stretching out a hand of assistance in upholding the Telegraph Company. No response was made to the suggestion for Imperial subsidy. In 1877, however, the Secretary of State for the Colonies recommended that Jamaica should give a subsidy of £3,000 per annum. Upon considering this proposition the Legislative Council agreed to give £1,000 per annum subsidy, on condition of publishing daily in Kingston a bulletin of news giving—

(1) Important political news from all parts of the world.
(2) Price of Colonial products in New York and London.
(3) Prices of staple articles of sale in the Colonies.
(4) Inter Colonial news.
(5) Movements of steamers, with the names of passengers for the West Indies.
(6) Official appointments, &c.

The company expressed their willingness to accept a subsidy of £2,000 per annum upon the considerations proposed by the Legislative Council, and this grant was sanctioned in 1879. In 1880 the Board of Directors deputed Mr. Richard C. Grosvenor to visit the West Indies in the interests of the company, and "to place before the several Governments the precarious position of the company's system in the West Indies, to see that the revenues derived from it are insufficient for its efficient maintenance, and to ask for a renewal of the Telegraph Acts with larger grants and modifications of the terms." In 1881, Mr. Grosvenor visited Jamaica to urge the proposals suggested by the company, while in 1882 representatives of the West India Colonies—to which no delegate was sent from Jamaica—convened at Barbadoes considered the question of subsidies, and made suggestions to Her Majesty's Government, which, after full consideration, they could not agree to. In 1886, Governor Sir Henry Norman laid a message before the Legislative Council with reference to the desire for some improvement in the telegraphic messages. He stated that it seemed inevitable that the messages should be compiled in New York to save cost of transmission across the Atlantic, and he also stated that while the messages must be adapted as far as possible to the requirements of all West Indian Colonies, the company was most willing to accept any practical suggestions for improvement that might be made from Jamaica. No action was taken, and the agreement of 1879 continued. It will be seen that the company throughout has been anxious to comply with the demands of the inhabitants as far as possible.

"UNDERWRITERS' WIRE."—We mentioned recently that the use of the insulated wire known in the States as "underwriters' wire," for electric lighting leads, had been expressly condemned in a resolution voted unanimously by the representatives of the American Edison Companies. So far as we are aware no specimen of this meretricious production has drifted to this side of the Atlantic, and many of our readers are therefore probably unaware of its nature. At the very beginning of electric lighting business in America the underwriters laid down a single condition with regard to the wiring—that the insulation must be uninflammable. It is needless to remark that this condition is a highly desirable one, but in practice it has usually to give way to some extent to the far more important question of adequate insulation, with which the underwriters did not suppose themselves to be immediately concerned. The study of the Phœnix Fire Office rules, to which the American offices have since betaken themselves, has doubtless tended to open their eyes upon this and many other points of a similar character. However, the dictum had gone forth, a fireproof insulation was demanded, and a fireproof *covering* was speedily placed on the market. The fact that the material was more or less incombustible being easily demonstrated, the further question of whether or not it possessed any insulating property worth speaking of was left for experience to determine. Experience has now settled the question, with the result embodied in the resolution referred to. The material known as underwriters' wire consisted of a cotton braid, painted with white lead. Cotton, as every electrical student is aware, is in itself an excellent insulator—the only, but sufficient, objection is that cotton when exposed in any degree to the atmosphere cannot be induced to remain in a moderately dry condition, and *damp* cotton is one of the most undesirable materials to employ for the purpose in view. The notion that this difficulty might be overcome by the addition of white lead as a paint is one which might, perhaps, fairly have been made the subject of preliminary trial, but that the material should have come into such extensive use (in America) as to have received a practical demonstration on the scale of some 100 or more disasters caused thereby is decidedly matter for regret. We give the above figure on the authority of Mr. Barrett, the well-known electrician to the City of Chicago. Mr. Barrett, in a paper which he read before the recent Convention of the National Association of Fire Engineers at Atlanta, stated that he had recently addressed a series of questions on the subject of electricity to the local authorities in the principal cities of America, from which he gathered that there had been hitherto 137 fires caused in this way, resulting in the loss of $1,165,336. Mr. Barrett was evidently of opinion that the greater portion of these accidents were due to the employment of underwriters' wire. We hasten to add, for the benefit of any of the outside public whom this paragraph may reach, that the wire in question is, we believe, absolutely unknown in this country, and further that wherever installations are carried out in accordance with the regulations known as the Phœnix Fire Office rules (which are almost universally followed in this country) no damage from fire caused by electric lighting has ever been known to occur.

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THE EMPLOYMENT OF A SHUNT WITH THE BALLISTIC GALVANOMETER.

BY E. C. RIMINGTON.

If two quantities of electricity are to be compared by means of a ballistic galvanometer, and one of them is much greater than the other, it is generally necessary to shunt the galvanometer when the larger quantity is discharged through it, so as to obtain the throws about the same in each case. If the quantities which are passed through the galvanometer are obtained from the discharge of a condenser, it is well known that the value of the multiplying power of the shunt can be written $\frac{G+S+k}{S}$, where G is the resistance of the galvanometer, S that of the shunt, and k is a constant depending only on the galvanometer, and which can be obtained by experiment, so that the galvanometer behaves as if it had a resistance $G+k$ instead of G. When, however, the quantity to be measured is obtained by altering the value of the magnetic field within a coil, which is connected to the shunted galvanometer, the case is somewhat different, and may be investigated in the manner shown in Fig. 1.

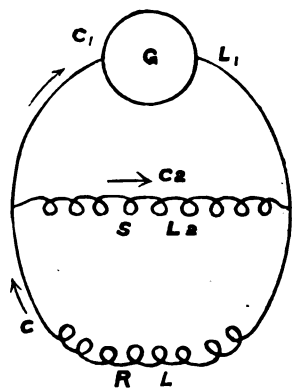

FIG. 1.

Let G, S, and R represent the resistances of the galvanometer, shunt, and coil; let L_1, L_2, and L be their coefficients of self-induction; suppose them to be so placed that the co-efficient of mutual induction between any two of them is zero, as would be the case in practice. Let E be the E.M.F. acting in the coil at any instant, and let C_1, C_2, and C be the currents in the galvanometer, shunt, and coil at the same instant. Then we have:

$$C = C_1 + C_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$C R + C_2 S + L\frac{dC}{dt} + L_2\frac{dC_2}{dt} = E \quad . \quad . \quad . \quad (2)$$

$$C_1 G - C_2 S + L_1\frac{dC_1}{dt} - L_2\frac{dC_2}{dt} + a\,.\,\frac{d\sin x}{dt} = 0 \quad . \quad (3)$$

$a\,.\,\frac{d\sin x}{dt}$ represents the E.M.F. induced in the coils of the galvanometer by the motion of the needle.

The number of lines of force due to the needle which pass through the galvanometer coils is proportional to $\sin x$, and consequently the E.M.F. induced in them to $\frac{d\sin x}{dt}$, or is equal to $a\frac{d\sin x}{dt}$, where x is the angle the needle makes with the plane of the coils and a is a constant depending on the geometry of the coils and the magnetic moment of the needle.

From (1) and (3)—

$$C_1(G+S) - CS + L_1\frac{dC_1}{dt} - L_2\frac{dC_2}{dt} + a\frac{d\sin x}{dt} = 0.$$

$$(G+S)\int C_1\,dt - S\int C\,dt + L_1\int dC_1 - L_2\int dC_2 + a\int d\sin x = 0.$$

If this be integrated between the limits time equals zero and the time when the needle is at the end of its first throw, $\int C_1\,dt = q_1$, the quantity passing through the galvanometer; $\int C\,dt = Q$, the total quantity which passes through the circuit; $\int dC_1$ and $\int dC_2$, both equal zero because, by supposition, the time the E.M.F. acts in the coil R must be very small compared to the time of swing of the galvanometer; also the E.M.F. due to the swinging needle is zero at the end of a throw, as at that point the needle is at rest. $\int d\sin x = \sin\delta$, where δ is the throw obtained. So we have

$$(G+S)q_1 - SQ + a\sin\delta - 0.$$

Now, if the galvanometer employed be a reflecting one, δ will always be a small angle, and consequently $\sin\delta = 2\sin\frac{\delta}{2}$ approximately; but, by the principle of the ballistic galvanometer, $\sin\frac{\delta}{2}$ is proportional to the quantity that passes through the instrument, so we may write $\sin\delta = bq_1$; b is a constant depending on the geometry of the coil, the magnetic moment of the needle, and the controlling field.

Therefore $(G+S)q_1 - SQ + abq_1 = 0$;

or, $Q = q_1\frac{G+S+k}{S}$ (4) where $k = ab$ and depends only on the galvanometer.

Again, from equations (1) and (2),

$$(R+S)\int C\,dt - S\int C_1\,dt + L_2\int dC_2 + L\int dC = \int E\,dt$$

$$(R+S)Q - Sq_1 = \int E\,dt.$$

Now, $$\frac{\int E\,dt}{R+\frac{GS}{G+S}} = Q_0,$$

the total quantity which would pass through the circuit if there were no motion of the galvanometer needle.

Therefore $$(R+S)Q - Sq_1 = Q_0\left(R+\frac{GS}{G+S}\right),$$

or $$Q = \frac{Q_0\left(R+\frac{GS}{G+S}\right)+q_1S}{R+S} \quad . \quad . \quad . \quad . \quad (5)$$

From (4) and (5)

$$\frac{Q_0\left(R+\frac{GS}{G+S}\right)+q_1S}{R+S} = q_1\frac{G+S+k}{S};$$

$$Q_0 = q_1\left\{\frac{(G+S+k)(R+S)}{S} - S\right\}\cdot\frac{G+S}{R(G+S)+GS},$$

$$= q_1\frac{G+S}{S}\cdot\frac{R(G+S)+GS+k(R+S)}{R(G+S)+GS},$$

$$= q_1\frac{G+S}{S}\left\{1+\frac{k(R+S)}{R(G+S)+GS}\right\},$$

$$= q_1\cdot\frac{G+S}{S}\cdot\left(1+\frac{k}{G+\frac{RS}{R+S}}\right).$$

Now, $$\int E\,dt = Q_0\cdot\left(R+\frac{GS}{G+S}\right) = Q_0\cdot\frac{R(G+S)+GS}{G+S};$$

$$\therefore \int E\,dt = q_1\cdot\frac{R(G+S)+GS+k(R+S)}{S},$$

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$$G+k = S\,.\,\frac{D_1\,.\,\dfrac{K_2}{K_1} - D_2}{D_2},\ \text{and}\ k = S\,.\,\frac{D_1\,\dfrac{K_2}{K_1} - D_2}{D_2} - G.$$

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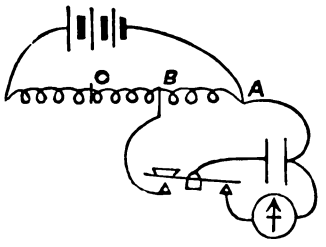

FIG. 2.

So $$\frac{R_2}{R_1} = \frac{D_2}{D_1}\,.\,\frac{G+k+S}{S},$$

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THE EMPLOYMENT OF A SHUNT WITH THE BALLISTIC GALVANOMETER.

BY E. C. RIMINGTON.

If two quantities of electricity are to be compared by means of a ballistic galvanometer, and one of them is much greater than the other, it is generally necessary to shunt the galvanometer when the larger quantity is discharged through it, so as to obtain the throws about the same in each case. If the quantities which are passed through the galvanometer are obtained from the discharge of a condenser, it is well known that the value of the multiplying power of the shunt can be written $\frac{G+S+k}{S}$, where G is the resistance of the galvanometer, S that of the shunt, and k is a constant depending only on the galvanometer, and which can be obtained by experiment, so that the galvanometer behaves as if it had a resistance $G+k$ instead of G. When, however, the quantity to be measured is obtained by altering the value of the magnetic field within a coil, which is connected to the shunted galvanometer, the case is somewhat different, and may be investigated in the manner shown in Fig. 1.

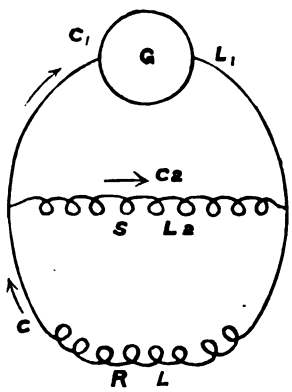

Fig. 1.

Let G, S, and R represent the resistances of the galvanometer, shunt, and coil; let L_1, L_2, and L be their coefficients of self-induction; suppose them to be so placed that the co-efficient of mutual induction between any two of them is zero, as would be the case in practice. Let E be the E.M.F. acting in the coil at any instant, and let C_1, C_2, and C be the currents in the galvanometer, shunt, and coil at the same instant. Then we have:

$$C = C_1 + C_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$C\,R + C_2\,S + L\frac{dC}{dt} + L_2\frac{dC_2}{dt} = E \quad . \quad . \quad . \quad (2)$$

$$C_1\,G - C_2\,S + L_1\frac{dC_1}{dt} - L_2\frac{dC_2}{dt} + a\,.\,\frac{d\sin x}{dt} = 0 \quad . \quad (3)$$

$a\,.\,\frac{d\sin x}{dt}$ represents the E.M.F. induced in the coils of the galvanometer by the motion of the needle.

The number of lines of force due to the needle which pass through the galvanometer coils is proportional to $\sin x$, and consequently the E.M.F. induced in them to $\frac{d\sin x}{dt}$, or is equal to $a\frac{d\sin x}{dt}$, where x is the angle the needle makes with the plane of the coils and a is a constant depending on the geometry of the coils and the magnetic moment of the needle.

From (1) and (3)—

$$C_1(G+S) - CS + L_1\frac{dC_1}{dt} - L_2\frac{dC_2}{dt} + a\frac{d\sin x}{dt} = 0.$$

$$(G+S)\int C_1\,dt - S\int C\,dt + L_1\int dC_1 - L_2\int dC_2 + a\int d\sin x = 0.$$

If this be integrated between the limits time equals zero and the time when the needle is at the end of its first throw, $\int C_1\,dt = q_1$, the quantity passing through the galvanometer; $\int C\,dt = Q$, the total quantity which passes through the circuit; $\int dC_1$ and $\int dC_2$, both equal zero because, by supposition, the time the E.M.F. acts in the coil R must be very small compared to the time of swing of the galvanometer; also the E.M.F. due to the swinging needle is zero at the end of a throw, as at that point the needle is at rest. $\int d\sin x = \sin\delta$, where δ is the throw obtained. So we have

$$(G+S)\,q_1 - S\,Q + a\sin\delta - 0.$$

Now, if the galvanometer employed be a reflecting one, δ will always be a small angle, and consequently $\sin\delta = 2\sin\frac{\delta}{2}$ approximately; but, by the principle of the ballistic galvanometer, $\sin\frac{\delta}{2}$ is proportional to the quantity that passes through the instrument, so we may write $\sin\delta = bq_1$; b is a constant depending on the geometry of the coil, the magnetic moment of the needle, and the controlling field.

Therefore $(G+S)\,q_1 - S\,Q + ab\,q_1 = 0$;

or, $Q = q_1\frac{G+S+k}{S}$ (4) where $k = ab$ and depends only on the galvanometer.

Again, from equations (1) and (2),

$$(R+S)\int C\,dt - S\int C_1\,dt + L_2\int dC_2 + L\int dC = \int E\,dt$$

$$(R+S)\,Q - S\,q_1 = \int E\,dt.$$

Now, $$\frac{\int E\,dt}{R + \frac{GS}{G+S}} = Q_0,$$

the total quantity which would pass through the circuit if there were no motion of the galvanometer needle.

Therefore $$(R+S)\,Q - S\,q_1 = Q_0\left(R + \frac{GS}{G+S}\right),$$

or $$Q = \frac{Q_0\left(R + \frac{GS}{G+S}\right) + q_1 S}{R+S} \quad . \quad . \quad . \quad . \quad (5)$$

From (4) and (5)

$$\frac{Q_0\left(R + \frac{GS}{G+S}\right) + q_1 S}{R+S} = q_1\frac{G+S+k}{S};$$

$$Q_0 = q_1\left\{\frac{(G+S+k)(R+S)}{S} - S\right\}\cdot\frac{G+S}{R(G+S)+GS},$$

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Now, $$\int E\,dt = Q_0\cdot\left(R + \frac{GS}{G+S}\right) = Q_0\cdot\frac{R(G+S)+GS}{G+S};$$

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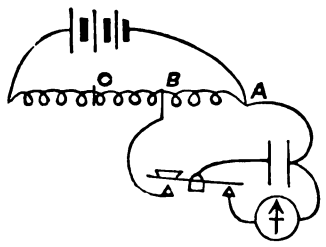

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All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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CONCERNING ELECTRICAL ENGINEERS.

Our mention last week of an American example which it would be wise if the Electrical Engineers of this country were to follow has met with such favourable attention, and the suggestion we ventured to put forward in relation to it has called forth so many responses, both oral and in writing, that we think it worth while to speak more at length of the scheme while it is fresh in the minds of our readers. It was the American Electric Light Convention that gave rise to the idea, a Convention which is already doing good practical service in the States, and if imitated here on the broader basis which the circumstances of this country seem to demand, would be not less advantageous to British Electrical Engineers. That something of the kind has long been felt to be needed is testified by our correspondence columns, where from time to time discussions on questions arise that can be thrashed out thoroughly only by that personal intercourse and comparison of experience which a public meeting or convention adequately affords. The questions to which we are now alluding are almost exclusively of the practical sort, neither theoretical nor scientific, though of course these latter elements are not excluded by the fact that the conditions of practical work would be esteemed of primary importance by practical men. Neither the meetings of the Society of Telegraph-Engineers and Electricians, nor of any other society that we can call to mind, at all provide what we are desiderating, namely, the bringing together of business men to discuss and promote the special callings in which they are engaged.

The Electric Light business in America is already so extensive that it can command a very respectable "Convention" all to itself. This would probably not be the case in England, where any assembly of the kind might properly include not only Electric Light but Electric Locomotive and Electric Telegraph and Telephone-Engineers. And what we suggest is that they should combine to at least this extent, namely, to meet either as a body or by delegation once or twice a year in order to consider how best they may protect and advance their corporate interests. We have examples of such combination even on this side of the Atlantic. The Mechanical Engineers and the Iron and Steel Institute are illustrations of what we mean, neither of which clash in any way with the Institution of Civil Engineers, the functions of which, like those of the Society of Telegraph-Engineers, being scientific and professional rather than commercial. The aim of Societies like those just named may be roughly described as that of providing their members with the equipments of their trade; the aim of the subsidiary Association or Convention the formation of which we are advocating would be, on the other hand, to turn that professional equipment to the best account, and would consequently be welcome to members of various and differing Societies. In this respect it would resemble the meeting of the British Association; but, unlike that miscellaneous gathering, its object would be not to promote either science or business in general, but a particular business representing a particular branch of applied science.

The term Convention, which the Americans have borrowed from the French, is not altogether adapted for English use. It is at once too big and too little, smacking rather of the Revolution at one extreme and the Caucus at the other. Association would be equally explanatory of its object, and besides being more accurately descriptive of its organisation would be more friendly and co-operative in its signification. We all know that an Association meets for a common object; the Associated Chambers of Commerce answers this description pretty exactly. Nobody knows beforehand what a Convention may be convened to say or do; and the historical example above alluded to, separating to cut each other's throats, is not a point in its favour. But, whatever its designation, the assembly might be easily organised, and the expenses attending it would be quite trivial. Let a beginning be made as soon as practicable; a committee formed, a secretary appointed, and a meeting called, adherents will speedily come in. An Association of Electrical Engineers has on the face of it an inviting look to the practical eye, and we feel pretty confident that in a very short time such an Association would muster a very strong roll of members.

In our comments on the American "Convention" we observed that the scientific papers on electric lighting, to which it is almost exclusively devoted, are not of a very high order. It is no disparagement to say this in the case of America, because we know that much allowance has to be made for keeping up the oratorical standard, and that science lends itself to this object almost as readily as politics, though not often with such edifying results. There is no fear of our proposed Association yielding to the temptation of high science or high faluting of any kind if its practical objects be steadily kept in view from the outset. It is needless to enumerate what those objects are to be, they will arise as circumstances may determine; but subjects of great and immediate importance are ripe for discussion even at this moment. For example, there is the Electric Lighting Act, there is the local opposition to Telephone Wires and Electrical Railroads, and there are the Fire Insurance Rules. It is an open secret that the provisions of Mr. Chamberlain's Act were originally accepted, if not actually

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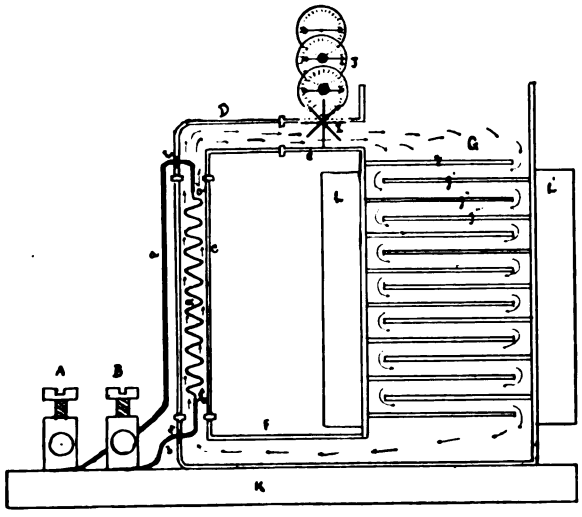
suggested, by electrical engineers, who, with no doubt the best intentions, gave it their approval on the supposition that it was better than no Act at all, but who, had there existed any cohesion in the profession or opportunity for a full discussion, would certainly have acted quite differently. The reform of this measure is urgently needed, and the shape it ought to take can only be settled satisfactorily by mutual and friendly interchange of views among those whom it chiefly concerns. And in this way, too, their relations with local authorities, often very strained and captious, would be placed on a sound footing. As touching the regulations for installations in respect to fire risks, it is high time the question was settled whether the Phœnix rules are to be recognised as obligatory all round, or whether some other authority is to be allowed to step in and make matters more confusing than ever. With such questions as these the members of a corporate body could deal decisively and with full regard to their own interests; as separated individuals they can do nothing.

CORRESPONDENCE.

ANOTHER CURRENT METER.

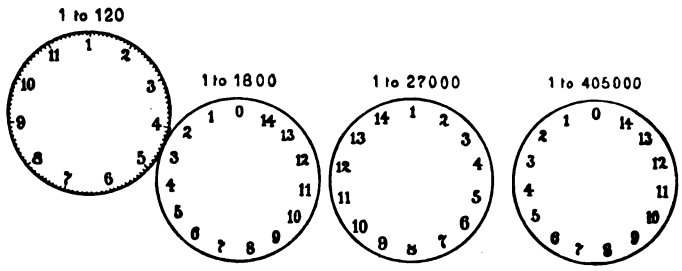
TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your paper of the 23rd inst. has just arrived, and reading the interesting article of Prof. Forbes upon his current meter, we wish to give you a description of a meter we made in June, 1883. Enclosed you will find a cross section of the



Cross Section of Jehl and Rupp's Current Meter

meter and also a printed dial we had made at the time. We called it an ampere register, but no doubt we would give it a better name to-day. The meter consisted of a glass tube, *c*, both ends of which were fitted into two bent pieces of piping, D and F, as shown. Through these bent tubes D and F passed the wires *a* and *b*, which were connected to the binding posts A and B. The part of the wire where it passed into the tubes was well insulated. At the ends *a'* and *b'* was connected the coil R, which consisted simply of a few turns of copper wire whose diameter was less than the leading wires *a* and *b*. To the tube D was attached a square tube, E, which had a little opening at the top so as to permit a small undershot wheel, I, to revolve freely. This undershot wheel was well pivoted and constructed very light. To the axis of this wheel was connected another system of wheels with indicators, as shown, J. Now, the tubes E and F were connected to a reservoir, G. This reservoir consisted of a square tank, in the inside of which were soldered in an alternating manner square sheets of copper as shown in the drawing *g g' g'' g'''* . . . . These sheets acted as diffusers. These plates or sheets presented a very large surface. On the outside of the tank G were also diffusers *h h'* . . . . arranged all round and presenting an appearance as if two books were open so as to form a square with their covers, the leaves being the diffusers. The diffusers on the outside were at right angles to those inside.



Dial Face.

The action of the meter was thus:—When a current passes through the coil R it heats the liquid at the place, thus causing a circulation, the warm liquid ascending while the cold liquid descends as shown by the arrows. This circulation causes the undershot wheel to revolve, and its revolutions are registered by the clockwork. The stronger the current the more the heat, and thus the more rapid the circulation. The warm liquid once in the tank, which is of a reasonable size, will impart its heat to all the diffusers. The surface of the glass tube, &c., is very small in comparison to the surface of the tank. It will be seen that the function of this apparatus is independent of the outward temperature, for the motion of the liquid is due only to that heat which is generated by the current. When the current does not pass, it is evident that the liquid, at whatever temperature it may be, does not circulate, as all parts are of the same temperature, but the moment the current passes a difference is produced, which causes a circulation in proportion to the current. We may mention that we tried various liquids, and give preference to pure olive oil. It will also be seen that this meter is good for alternating currents. In conclusion, we may remark that the tests we made gave satisfaction, and we wanted to publish them, but that Mr. Jehl was called away to fit up the Edison exhibit in the Vienna Exhibition for the Société Electrique Edison of Paris. After the exhibition we began our work upon our disc machine, and had almost forgotten our meter.—Yours, &c., JEHL AND RUPP.

Brünn, Sept. 26, 1887.

P.S.—The whole apparatus is mounted on a base, K.

TELEPHONIC INTERCOMMUNICATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 430 of last issue, under heading of "Western Counties Telephone Company," you speak of telephonic communication between towns as an "experiment."

Permit me to say that my company has had such an "experiment" in successful operation for several years. Out of our total length (at 30th June) of *7,253* miles of wire, no less that *2,400* is employed solely for inter-town work.

Quite 50 per cent. of our subscribers regularly use these trunk-wires, and our income from this source alone is at the rate of nearly *£7,000* per annum.

Referring to another matter alluded to in your paragraph, I may say that our subscribers have all along been allowed to telephone *direct from their own offices*. At the option of subscribers, payment can be made either by a fixed sum yearly in advance or by a toll per message. In the latter case the company keeps a record of the inter-town "calls," and furnishes a monthly account.

The popularity of this "toll" system may be judged from the fact that the aggregate of these subscribers' monthly accounts is at the rate of nearly *£3,000* per annum, and each month shows a steady increase.

The *yearly* rentals of trunk wires yield about *£2,200* per annum; the balance of the £7,000 above mentioned is paid by

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the general public, for whose convenience we have opened more than one hundred call offices in our district.

By inserting this letter in your next issue you will oblige, Yours, &c.,

KENNETH MACIVER, Secretary and General Manager,
Lancashire and Cheshire Telephone Exchange Company (Limited).

38, Faulkner-street, Manchester, October 4, 1887.

[We need scarcely assure our correspondent that we are already fully aware of the success of inter-urban telephony in the North of England. The note referred to the introduction of the service in the less busy districts of the West, where it must for the time being be regarded as a financial "experiment."—ED. *E.*]

THE PROPOSED ASSOCIATION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of the 30th ult. a suggestion that a Society of English Manufacturers and Practical Electricians—after the lines of the Electric Light Congress in America—would encourage business in electrical engineering on this side of the water. I cannot say that I know much about the doings or objects of the American Society, but it seems to me that if the discussions of the English Society were limited to the business done in England it would have very little to talk about. Any movement calculated to rouse the British lion out of his present torpid condition should meet with the support of all electricians, and such a society as you propose could, I believe, exercise a beneficial influence on electrical business by banding together electricians and contractors of standing, and using its influence to raise (more or less) the standard of work done by installation engineers. There are many installations of first importance in this country which are doubtful successes—not to mention those which have been abandoned altogether—and there is no doubt that these exercise a depressing influence on the state of electric lighting in this country.

I maintain that many of these failures are attributable to want of knowledge or experience on the part of the contractors. Persons who do not know anything about calculating out their sections for conductors, or suitability of certain dynamos or engines for the particular work in hand, rush in and set up an installation. They, in many cases, get good engines, good dynamos, good lamps, &c., and yet combine the whole in such a haphazard manner that the result is horrible. Sometimes it is simply the section of the conductors that is at fault, but sometimes it is a matter not quite so much on the surface. Thus, about a year ago I sent eight arc lamps designed for series burning with a current of 12 amperes to some installation engineers in the north. On starting the installation my friends wrote that the lights were not steady, and I went up north post haste. On arriving at the installation I found the lamps had a slow pulsation, going low, and then gaining brightness up to great brilliancy; then sinking gradually lower and lower, and then up again, the whole cycle taking place in about half a minute, and being repeated sometimes three or four times in succession, and sometimes only at intervals of two or three minutes. I saw what the matter was at once, and made my way to the engine shed. There I found a Fowler engine and Mather and Platt dynamo. Here was a very good set of plant; engine, dynamo, and lamps all very good, and yet giving abominable results. On looking at the ammeter I found, as I had anticipated, that the current was fluctuating between 15 and 8 amperes (as nearly as I can now remember).

The explanation is this:—My lamps were designed to feed at 12 amperes. The iron in the Mather and Platt dynamo was not magnetically saturated at 12 amperes, or, in other words, the terminal curve of E.M.F. was a rising one at 12 amperes, and since my lamps have a "pull back"—which every good lamp should have, Mr. De Wolffers notwithstanding—the combination was an impossible one. The obvious thing to do was to make the lamps feed at a higher current, which I did, altering them to feed at 15 amperes, when all the irregularities disappeared and the installation gave satisfaction. Of course, my friends should have specified to the dynamo makers that the machine should reach the summit of its curve of E.M.F. at the terminals at a lower current than 12 amperes (say 10—11). But one could hardly be annoyed with them for coming to grief in this respect a year ago, taking into consideration that it seems to be a point of honour among English installation engineers *not to know* anything at all about arc lights. However, the fact remains that an installation went very near being condemned, in which all the plant was high class, simply for the want of a little ordinary electrical knowledge.

I could give four more instances in which this very point has cropped up and damaged an arc installation; and if these five instances have come under my observation, how many must have occurred and possibly remained uncorrected, to the detriment of electric lighting?

Another *pons asinorum* of *soi disant* electricians is the coupling of compound-wound machines to work in parallel; but one might go on for ever through the list of unsuitable belts, engines of too slow speed, &c. My point is that a society having for its members sound practical electricians and engineers only, and striving to shake the practice of electrical engineering into something like an art, having some definitive rules and principles—not a sort of "go-as-you-please" business, as at present—and at the same time keeping an eye upon the work done by all installation engineers, whether members or outsiders, would be calculated to benefit and develop electric light in this country, and to such a society I should give my unqualified adherence.—Yours, &c,

J. GRICE STATTER.

P.S.—I should explain, for the benefit of those who are not electricians, that *all* dynamos used for driving arc lights should have reached the highest point of their curve of E.M.F at the terminals at a current somewhat less than that at which the lamps feed, and that my lamp is not in any way peculiar in this respect.

West Drayton, Oct. 3, 1887.

"WHAT IS ELECTRICITY?"

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As you have found my paper, "What is Electricity?" of sufficient interest to publish an abstract of it, I think that you may be interested in some further remarks on the subject, the more especially as I find that my readers here have misapprehended some of my statements, and also your editorial remarks thereon.

My position is not that in a mathematical sense electricity cannot be expressed in terms of length, time and mass, but that being so expressed it does not follow that it is one of these, nor force, energy, or anything else except electricity.

My meaning will be made more apparent by an illustration. We can and do express energy graphically by an area, as in the pressure diagram of a steam engine. The co-ordinates being respectively equal numerically to the movement of the piston and the pressure, the area of the figure is numerically equal to the work done. Now, no one supposes in consequence that energy is really an area, or that the relation is anything more than a numerical one.

Much as I respect anything emanating from so profound a scientist as Prof. Tait, I can find no philosophical reason for regarding force as any more of a "cloud wrapped mystery" than energy.

Neither can I see, with the popular eye, any more mystery in electricity as a distinct entity than in heat.

To regard one of these phenomena as a starting point, and express the others in terms of it, may serve a useful purpose, but it does not prove that the other phenomena are but manifestations of the first, which is alone an objective reality.

That any scientific man should hold electricity (*e.g.*, quantity of electricity) to be energy seems to predicate that he must have some other unit than the electrostatic or electro-

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magnetic units in his mind. The dimensions of energy are $[L^2M\,T^{-2}]$ of energy referred to unit of time $[L^2M\,T^{-3}]$.

The dimensions of quantity of electricity are in the electro static system $[L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}]$, and in the electro-magnetic system $[L^{\frac{1}{2}}M^{\frac{1}{2}}]$. In order to make up the dimensions of energy we must multiply these expressions by $[L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}]$ and $[L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}]$ respectively, which are exactly the respective dimensions of electromotive force in the two systems.

It is therefore the product of electricity and E.M.F. that is energy, and not electricity alone.

The dimensions of current are in the two systems $[L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}]$ $[L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}]$, which being multiplied by the respective dimension of E.M.F. gives the dimensions of energy per time $[L^2M\,T^{-3}]$, and we must still multiply by a time to get energy. Electricity regarded as a flux may be expressed as a surface integral in the same way as quantity of heat.

Now this quantity of heat is certainly energy; but it does not follow therefrom that electricity is energy, any more than the fact that an equation of similar form to the equation of continuity in hydro-dynamics holds true in the case of electric currents proves that electricity, like water, is a material, incompressible fluid. Similar arguments to the above apply to the case of the supposition that electricity is matter. It certainly is not mass, but if it is contended to be a kind of matter which possesses no mass or other attribute which would interfere with its being electricity I will offer no objection.

In regard to the Faraday and Maxwell theory of stress in a dielectric, I will say that the mathematics of stress may figure out ever so well, but as a vacuum acts as a dielectric, before we can say that a real stress exists we must first know whether a vacuum is really a vacant space or not.

Maxwell himself likens his theory to the process of differentiation, and the theory of attraction at a distance to integration. Is there any more objective reality to one process than the other?—Yours, &c., TOWNSEND WOLCOTT.

828, Monroe-street, Brooklyn, N.Y., U.S.A.
Sept. 19th, 1887.

THE LIGHTING OF THEATRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In lighting a theatre by electric light will some electrician kindly inform me what precautions are of avail to prevent a disastrous fire any time a wire is broken, as it is alleged that in such a case an arc light is at once set up between the broken ends which would speedily set on fire any articles of an inflammable nature in the neighbourhood?—Yours, &c., SAFETY.

October 1st, 1887.

ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.—XLVI.

BY OLIVER HEAVISIDE.

Cancelling of reflection by combined resistance and bridge. General remarks. True nature of the problem of long-distance telephony. How not to do it. Non-necessity of leakage to remove distortion under good circumstances, and the reason. Tails in a distortional circuit. Complete solutions.

Having in Sections XLIV. and XLV. discussed in some detail the effects due to resistances inserted in, and also those due to conducting bridges across, a non-distortional circuit, which are of fundamental importance, and which lead to the development of a positive tail by a continuous distribution of resistance in excess of the non-distortional amount, and of a negative tail by an excess of leakage, the full investigation of the case of resistance and leakage combined in any proportions presents no difficulty.

Start with a circuit having no resistance and no leakage, which is therefore both non-distortional and conservative (or characterised by the absence of attenuation), and let there be an isolated disturbance going from left to right, defined by $V_1 = Lv C_1$. Also, let there be, at a certain place X, a bridge across the circuit, of conductance k; and, at the same place, a resistance r inserted in the circuit. When our incident wave V_1 arrives at X, there result a reflected wave represented by $V_2 = -LvC_2$, and a transmitted wave $V_3 = LvC_3$.

Now, considering the moment when these are all at X together (corresponding elements, of course), we have the following two equations connecting the three V's:—

$$V_1 + V_2 = V_3(1 + r/Lv), \quad . \quad . \quad . \quad . \quad (56d)$$

$$C_1 + C_2 = C_3(1 + k/Sv + rk). \quad . \quad . \quad (57d)$$

The first is simply the expression of Ohm's law applied to the resistance r, and the second expresses the continuity of the current at X. [Remember that Lv and Sv are reciprocal, so that the sum of the second and third terms on the right of (57d) express the bridge current.] The equation (57d) may also be written

$$V_1 - V_2 = V_3\,(1 + k/Sv + rk), \quad . \quad . \quad . \quad (58d)$$

So that, by adding this to (56d) first, and then subtracting it, we obtain the desired ratios. Thus,

$$V_1/V_3 = 1 + r/2Lv + k/2Sv + \tfrac{1}{2}rk, \quad . \quad . \quad (59d)$$

$$V_2/V_3 = r/2Lv - k/2Sv - \tfrac{1}{2}rk, \quad . \quad . \quad . \quad (60d)$$

when written in the simplest manner. Of course the ratio V_2V_1, if wanted, is the quotient of (60d) by (59d).

We see that the reflected wave may be either of the same or of the opposite electrification to the incident; and that, in order to completely abolish the reflected wave, we require, by (60d),

$$r/Lv = k/Sv + rk, \quad . \quad . \quad . \quad . \quad . \quad (61d),$$

and that we then have, by (59d),

$$V_1V_3 = 1 + r/Lv \quad . \quad . \quad . \quad . \quad . \quad (62d)$$

simply. The reciprocal V_3/V_1 expresses the attenuation suffered by the incident wave in passing X.

The above equations are not in any way altered when we start with a real non-distortional circuit instead of an imaginary one of no resistance. But by adopting the latter course we are directed to the nearest approach to a physical explanation of the properties of the real non-distortional circuit itself. For, in the case of the circuit of no resistance we are dealing merely with progressive waves in a conservative medium, and we cannot expect to come to anything simpler than this. They simply carry their energy and all their properties forward at speed v unchanged, this speed being $(\mu c)^{-\frac{1}{2}}$, if μ be the inductivity and c the permittivity of the medium, which expression is equivalent to the other $(LS)^{-\frac{1}{2}}$, where L is the inductance and S the permittance, which is more convenient in the practical application concerned. Except in the matter of wave-length, these waves are identical with light-waves, with the peculiarity that the two (supposed) perfect conductors of our circuit prevent the waves from spreading in space generally, by guiding them definitely along the circuit. [The simplest case is that of a tubular dielectric bounded by perfect conductors, say an internal wire and an external sheath.] Now we prove by elementary principles, (Ohm's law, &c) that an inserted resistance, causing tangential dissipation of energy, produces a reflected wave of the positive kind, involving a redistribution, without loss, of the electrification on the bounding conductors; and a redistribution, with loss, of the corresponding magnetic quantity, the momentum. On the other hand, we show that a bridge causes a reflected wave of the negative kind, involving a redistribution, without loss, of the momentum; and a redistribution, with loss, of the electrification. [In speaking of redistribution, the mere translatory motion of waves is disregarded.] And by having both the bridge and the inserted resistance so proportioned as to make the loss of energy in each to be of the same amount (when small enough), we abolish the reflected wave, so that there is no redistribution, but merely attenuation produced by the resistance and bridge. This applies to any number of resistances inserted in the main circuit, each with its corresponding bridge; so that when we pack them infinitely closely together to represent continuously distributed resistance and leakage, we arrive at a real circuit, along which waves are propagated unchanged except in size. Thus any

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circuit (apart from interferences) may be made non-distortional by adding a suitable amount of leakage. This amount is usually too great for practical purposes. Nor is it required. In the very important problem of long-distance telephony, employing circuits of *low* resistance (which are the only proper things to use), making the well-known ratio R/Ln of the two components of the electromagnetic impedance small, say ½ or ¼, which may be easily done without using an extravagant amount of copper, we tend naturally, by bringing the inductance into relative importance, or equivalently, reducing the importance of the factor resistance, to a state of things resembling that which obtains in the truly non-distortional circuit (independent of frequency of variations) and approximate to non-distortional transmission. These statements may be proved by an inspection of the sinusoidal solutions I have given, but it would enlarge the subject too greatly to discuss them at present. I may, however, repeat that the problem of long-distance telephony is very remote from that of a long submarine cable which can only be worked slowly, unless we should unknowingly create a parallelism by employing quite unsuitable conductors; as, for instance, was done by the Post Office a few years since when they put down conductors having a resistance of 45 ohms per mile of circuit, combined with large permittance and small inductance; and then, to make the violation of electromagnetic principles more complete, put the intermediate apparatus in sequence, so as to introduce as much additional impedance as possible. The proper place for intermediate apparatus is in bridge, removing all their impedance completely. This method was invented and introduced into the Post Office by Mr. A. W. Heaviside. It makes a wonderful difference in the capabilities of a circuit, as is now pretty well known.

The theory of tails allows us to give an intelligible physical explanation of how it comes to pass that a perfectly insulated circuit, violating the non-distortional condition completely, will yet tend to behave in a non-distortional manner to waves of great frequency, provided the circuit be of a suitable nature, as above described. For let the circuit be so long that we can get several waves into it at once, when telephoning. They divide the circuit into regions of opposite electrification, each of which may (very roughly) represent what I have termed an isolated disturbance. Every one of them has its tail, but as they are alternately of opposite kinds, their residual effect in producing distortion becomes quite small. We can see clearly that the greater the frequency the less is the distortion, unless the increased frequency should bring with it increased resistance, which is very much to be avoided, and is what renders iron wire so unsuitable for *long*-distance telephony. By this mutual cancelling of the effects of the tails, we simulate the effect of the leakage which would wholly remove distortion, even of the biggest waves, without the disadvantage of the extra attenuation thereby introduced. I am induced to make these remarks rather out of their proper place as they illustrate the importance of the non-distortional circuit from the scientific point of view, in casting light upon the obscurities of distortional circuits.

From (59d) we can get some results relating to the tails of waves in a distortional circuit. Thus, let there be n bridges in the distance x, equidistantly placed, and each of conductance Kx/n, with a corresponding resistance Rx/n in the main circuit. Let a disturbance pass from beginning to end of the length x. If σ be the attenuation at each bridge, the total attenuation of the head of the disturbance produced by all the bridges and resistances is σ^n. Now make n infinite, keeping R and K finite. The total attenuation becomes, by (59d),

$$\sigma^n = \{1 + \mathrm{R}x/2\mathrm{L}vn + \mathrm{K}x/2\mathrm{S}vn + \mathrm{RK}x^2/2n^2\}^{-n}$$
$$= \epsilon^{-\mathrm{R}x/2\mathrm{L}v} \cdot \epsilon^{-\mathrm{K}x/2\mathrm{S}v} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (63d)$$

This is therefore the attenuation of the head suffered by every element in traversing the distance x, when R and K are the resistance and the leakage-conductance in any uniform circuit.

It will now be convenient to introduce a simpler mode of expressing the exponentials. Let

$$f = \mathrm{R}/2\mathrm{L}, \quad g = \mathrm{K}/2\mathrm{S}, \quad h = f - g, \quad q = f + g, \quad (64d)$$

all four being reciprocals of time-constants. Now (63d) becomes ϵ^{-qt} simply, if $t = x/v$ be the time of the journey over the length n. If, therefore, we have initially a disturbance $\mathrm{V}_0 = \mathrm{L}v\mathrm{C}_0$ extending through the small distance a, possessing the charge $\mathrm{SV}_0 a$ and the momentum $\mathrm{LC}_0 a$, then at the time t, later, when the disturbance extends over the distance $2x$, half on each side of its initial position, being a nucleus of length a and a tail of length $2x$, the charge and momentum in the nucleus become

$$\mathrm{SV}_0 a \cdot \epsilon^{-qt} \quad \text{and} \quad \mathrm{LC}_0 a \epsilon^{-qt} \quad . \quad . \quad . \quad . \quad (65d)$$

We have next to examine to what extent the total charge has attenuated by the leakage, and the total momentum by the resistance. This we can ascertain by (59d) and (60d), applied to find the loss of electrification caused by a single bridge and of momentum by a single resistance. Those equations give

$$\frac{\mathrm{V}_2 + \mathrm{V}_3}{\mathrm{V}_1} = \frac{1 + r/2\mathrm{L}v - k/2\mathrm{S}v - rk/2}{1 + r/2\mathrm{L}v + k/2\mathrm{S}v + rk/2}, \quad . \quad (66d)$$

$$\frac{\mathrm{C}_2 + \mathrm{C}_3}{\mathrm{C}_1} = \frac{\mathrm{V}_3 - \mathrm{V}_2}{\mathrm{V}_1} = \frac{1 + k/2\mathrm{S}v + \frac{1}{2}rk - r/2\mathrm{L}v}{1 + k/2\mathrm{S}v + \frac{1}{2}rk + r/2\mathrm{L}v}. \quad . \quad (67d).$$

These fractions, multiplied into the values of the charge and momentum respectively before the splitting, give their *total* values after the splitting. We can therefore apply the previous method of equidistant resistances and bridges to ascertain the method of subsidence of the total charge and momentum in the infinitely numerous splittings that occur in a finite time when we pass to the limit and have uniform R and K. Putting $\mathrm{r} = \mathrm{R}x/n$, &c., as before, and finding the limit of the nth powers of (66d) and (67d), we arrive at $\epsilon^{-\mathrm{R}t/\mathrm{L}}$ and $\epsilon^{-\mathrm{K}t/\mathrm{S}}$ respectively.

We thus see that a moving charge, no matter how it redistributes itself, subsides at the same rate as if it were at rest; for, obviously, $t\mathrm{S}/\mathrm{K}$ is the time-constant of the circuit regarded as a condenser, when uniformly charged and insulated at its terminations. It is *as if* electricity were atomic, so that we could follow the course of every particle. Thus, no matter how it moves about, it *shrinks* at the same rate as if it were at rest. Similarly as regards the momentum of the moving disturbance. Could we identify *its* elements, each would shrink in a manner independent of its translatory motions along the circuit. Notice also that the attenuation of the total charge equals the square of the attenuation of the nucleus due to leakage alone; whilst the attenuation of the total momentum equals the square of the attenuation of the nucleus due to resistance alone.

Thus, corresponding to (65d) we have—

$$\mathrm{SV}_0 a \cdot \epsilon^{-qt}(\epsilon^{-ht} - \epsilon^{-ft}) \text{ and } \mathrm{LC}_0 a \cdot \epsilon^{-ft}(\epsilon^{-ft} - \epsilon^{-qt}). \quad (68d)$$

to express the charge and momentum in the tail; since these, when added to (65d), make up the actual values otherwise found, viz., $\mathrm{SV}_0 a \cdot \epsilon^{-2qt}$ and $\mathrm{LC}_0 a \cdot \epsilon^{-2ft}$.

If $f > g$, or the resistance be in excess, the current in the tail is from head to tip, if that in the head be positive. But as time goes on, if the circuit be long enough, the head attenuates practically to nothing, leaving the big tail to work with. The region of positive current now extends from the vanishing nucleus a long way towards the middle of the tail, and in the limit the disturbance tends to become symmetrically arranged with respect to the origin from which it started as a positive wave, tailing off on both sides with the current positive on one side, and negative on the other.

But if $f < g$, or the leakage be in excess, a quite anomalous state of affairs occurs, which may be inferred from the preceeding by changing V to C, etc.

The full volutions of all tail problems (shape, growth, etc.) are contained in the following four equations. Let a charge SV_{0a} be at the origin at time $t = 0$, without any current. At time t we shall have, if $\mathrm{T} = \frac{h}{v}(x^2 - v^2t^2)^{\frac{1}{2}}$,

$$\mathrm{V} = \tfrac{1}{2}\frac{\mathrm{V}_{0a}}{v}\epsilon^{-qt}\left(h + \frac{d}{dt}\right)\mathrm{J}_0(\mathrm{T}), \quad . \quad . \quad (69d)$$

$$\mathrm{C} = \tfrac{1}{2}\frac{\mathrm{V}_{0a}}{\mathrm{L}v}\epsilon^{-qt}\left(-\frac{d}{dn}\right)\mathrm{J}_0(\mathrm{T}), \quad . \quad . \quad . \quad (70d)$$

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to express the double tail or band connecting the two nuclei at its ends, which are already known. Similarly, if there be initially a current at the origin, of momentum LC_0a, without charge, then at time t we shall have

$$C = \tfrac{1}{2}\frac{C_0 a}{v}\epsilon^{-\alpha t}\left(-h + \frac{d}{dt}\right)J_0(T), \quad . \quad . \quad . \quad 71d$$

$$V = \tfrac{1}{2}\frac{C_0 a}{Sv}\epsilon^{-\alpha t}\left(-\frac{d}{dx}\right)J_0(T). \quad . \quad . \quad . \quad . \quad 72d$$

As before, put on the two nuclei at the ends. Since the J_0 function is a simple one, viz.

$$J_0(T) = 1 - \frac{T^2}{2^2} + \frac{T^4}{2^2 4^2} - \frac{T^6}{2^2 4^2 6^2} + \ldots,$$

it is quite easy to follow the changes of shape by these formulæ, except when t has become large and the nuclei small, when other formulæ may be derived from the above which will approximately suit.

(To be continued.)

TELEPHONIC COMMUNICATION BETWEEN SHIPS AT SEA.—Lieut. Bradley A. Fiske, U. S. S. "Atlanta," has an interesting paper on the above subject in the *Electrical World* of September 24th, of which the following is the most important part:—"Having carried on for many months a laborious series of experiments in the direction of electrical communication between ships, possibly my conclusions may be interesting to anyone who contemplates attacking this subject, though I am able to point out chiefly the direction in which not to work, and to tell what things it would be useless to attempt. I experimented first with a view to signalling by induction, using first a bar electro-magnet about ten feet long, whose coils were traversed by a current of somewhat more than a hundred amperes, and for a receiver a pair of Bell telephones in circuit with coils of fine wire wrapped in various ways, one coil being wrapped around a groove cut in the circumference of a soft iron wheel about thirty inches in diameter. My apparatus assumed gradually larger and larger dimensions, till at length my sending electro-magnets were the iron masts of a ship wrapped with heavy wire; and finally I made an electro-magnet of the ship itself, wrapping her fore and aft with electric light wire, and sending through the wire the current of two Gramme dynamos coupled in multiple arc. As a receiver in this case I used an iron tug about 150ft. long and 25ft. broad, wrapped with fine wire in circuit with two Bell telephones. Though the results which I obtained were encouraging, they were not sufficiently good to indicate practical value, and I concluded to thoroughly test the plan first tried on a small scale by Prof. Bell, of using the water to complete the circuit of a generator, and to use as a receiver a small wire, having its terminals in the water and in circuit with two telephones. Of course, there was no doubt that communication could be held in this way; but the thing to determine was whether it could be held with any practicable length of wire. Evidently, the longer each wire the more current could be picked up by the receiving wire; but for practical use I concluded that each ship must be limited to wires one hundred yards long, and I therefore limited myself to this length in experimenting. For a long while I got very promising results with this method, simply making and breaking the current of the dynamos according to a code; but as I increased the distance the results became uncertain. I endeavoured to produce a sufficiently rapid alteration of the Gramme currents to make a musical sound in the telephone, noticing that to a distance of more than a hundred yards I could hear a pure sound, due to the minute variations produced by collector strips passing under the brushes; but I have not as yet succeeded in doing this satisfactorily. An alternating current dynamo might solve the problem, and I hope that some investigator having control of such a dynamo will try it."

ON INDUCTION BETWEEN WIRES AND WIRES.*

BY WILLIAM HENRY PREECE, F.R.S.

Last year at Birmingham I pointed out that the electro-magnetic induction between wire and wire upon lines of telegraph extended to distances much greater than was anticipated, and that effects were observed even when the wires were separated by the breadth of England. I was not satisfied with the last experiments made in the north of England. I had reason to believe that they were vitiated by induction and conduction through the network of cross circuits and railway wires in that part of the country, so in October of last year I took the district between Gloucester and Bristol along the banks of the Severn, where it was possible to completely isolate two systems of wire separated by the River Severn for a length of fourteen miles at an average distance apart of 4·5 miles, and where any disturbing cross-inductive or conductive connection was impossible. The circuits on each side of the river could be completed by the earth or by metallic returns passing far inland, in the one case through Monmouth, and in the other cases through Stroud.

The experiments made were very numerous, but the results were almost negative. No measurable effect whatever could be detected when primary currents of ·449 ampere strength were intermittently sent by a rapid vibrator or buzzer on each side, though it was just possible to distinguish faint Morse signals. It was quite clear from subsequent experiments that we were on the extreme verge of audibility, and had we been able at the time to increase the strength of our primary current we should have heard louder effects. In fact, I have taken this experiment as a measure of the limit of audibility—a conclusion fully confirmed by subsequent results. The experiments fully justified my conviction that those reported last year as occurring between Newcastle and Carlisle were wrong.

In all the following experiments the primary currents were always of rapid frequency, producing a buzzing sound, which could be easily read when audible, if sent in the Morse code, and received on a Bell telephone.

Two squares of 1,200 yards of gutta percha covered copper wire, or 300 yards each side, and of a resistance of fifteen ohms, were placed 300 yards apart in the Porchcawl Sands in South Wales, and conversation by the Morse code was readily maintained with primary currents of ·226 ampere. Conversation by telephone was impossible. Two other similar squares were subsequently (December) suspended on scaffold poles 15ft. above corresponding squares lying on the sands, which latter were covered with water when the tide was up.

No difference whatever could be detected in the strength of the signals received by induction, whether the space were air or water, or a combination of air and water. The Irish wires on the railway were 150 yards distant from the squares, and the usual disturbance was evident on all the squares, whether under water or not.

The principal object of this experiment was an endeavour to differentiate any electro-static from the electro-magnetic inductive effect, and the conclusion drawn was that the whole phenomenon was electro-magnetic, for no electro-static effect could be obtained. No doubt with parallel wires on a line of poles, where the distance between wire and wire is far less than that between wire and earth, electro-static induction comes into play, but its effect in the cases investigated was absolutely inappreciable.

This was confirmed by further experiments made with squares of 33ft. sides, fixed 3ft. apart.

Moreover, it tends to the conclusion that the magnetic field extends uninterruptedly through the earth as it does through the air, and that if the secondary circuit had been in a coal pit it would have been equally evident.

It also accounts for the peculiar disturbance observed in submarine cables when lying near each other as described in my previous paper. I hope to have the opportunity some day

* Paper read before the British Association Meeting at Manchester, September, 1887.

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of testing the limit of audibility in water. Cables, as a rule, lie too far apart for the purpose. I have made several efforts to get results on our Irish cables; but they lie apart far beyond the limit. Mr. Ash, the superintendent of the Eastern Telegraph Company at Porthcurnow, in Cornwall, joined a telephone to the ends of two cables, one terminating at Lisbon 820 miles away, the other terminating at Vigo, 620 miles away. Signals could be distinctly heard on the telephone from the Brest cable landing about half a mile away, and terminating at Penzance.

We happened during the autumn to be constructing a new trunk line carrying four copper wires from London to the coast of North Wales, and for many miles of its length in different places it ran parallel at various distances to the Great Western Railway. On Nov. 11th 1886, between Shrewsbury and Much Wenlock, 10¾ miles in length, a wire on the railway was made the primary wire, along which a periodic current of ·08 ampere was sent. Strong signals were

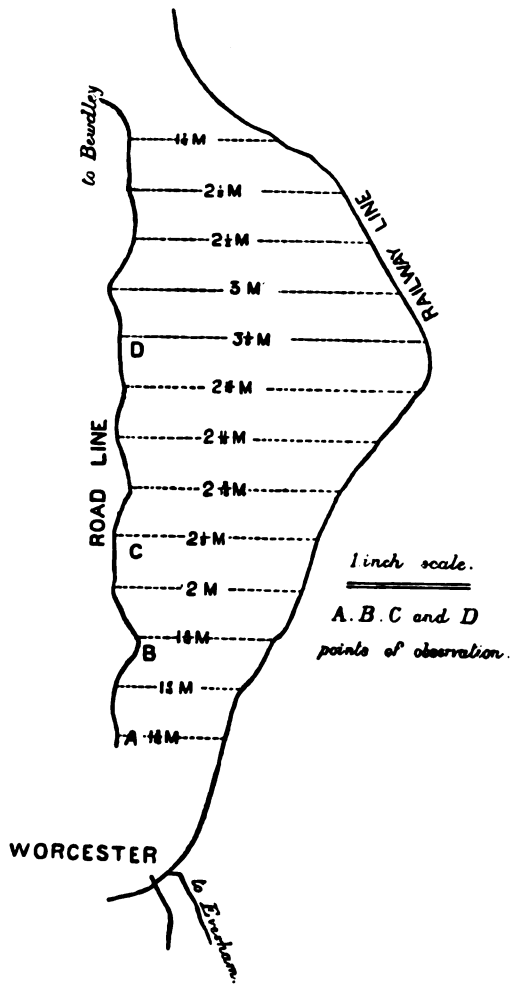

DIAGRAM A.

received on the copper wires, although they were completely isolated from any possible interference. The frizzling sound due to the ordinary induction from the mixed signals used in ordinary working were also evident, but the separating distance for 8 miles was only one quarter of a mile. Between Much Wenlock and Bewdley for a length of 12½ miles, where the separating distance averaged 1 mile 1,046 yards, the ordinary induction sounds entirely disappeared. On November 28th, 1886, similar experiments were repeated on a system of wires separated and isolated by the River Mersey for a distance of eleven miles. The primary circuit completed by the earth was on the Lancashire side. On the Cheshire side the secondary circuit was completed by a well-insulated metallic loop running inland, and measured 38½ miles in length. Morse signals were distinctly received. The separating distance was 1¼ mile. In February, 1887, the section between Worcester and Bewdley was divided into lengths, as shown in sketch Diagram A, page 25.

A wire on the railway was made the primary, the periodic current being ·12 ampere, but the results were *nil.** In no case could induction be heard between any of the points A, B, C, or D, or upon the whole length. Resort was again made to squares in a field near Cardiff, removed from all possible interference, and the standard of comparison made was the limit of audibility. This is not an absolute or a scientific standard to use, but it is practical. It depends on the variation of the human ear and the sensibility of the telephone receiver, but as the results recorded were always the conclusions of several persons, and the same telephone receiver was used in all cases, the normal ear may be assumed to have been used, and telephones do not differ much from each other when the same pattern is used. But they are much dependent on surrounding circumstances and extraneous sounds, on slight noises arising from the wind, from the rustling of the trees, from showers of rain, from passing persons or vehicles. The results of these experiments are given in the following table:—

TABLE A.

Experiments on induction at Lisvane, 2nd, 3rd, and 4th February, 1887.

Experiment.	Current in primary. C_1.	Working face of primary.	Working face of secondary. (l)	Resistance of secondary. r_2.	Limit of audibility. x.	Calculated results.
	Amperes.	ft.	ft.	Ohms.	ft.	ft.
1	·69	600	30	700	179	179
2	1·3	600	30	700	257	246
4	·69	600	60	700	585	
5	·69	600	30	700	182	
6	·69	600	30	200	641	641
7	·69	600	60	50	915	926
8	·69	600	90	76	1100	1134
9	·5	600	90	70	1373	1280

The extreme limit of audibility is derived from the Severn experiments, and is taken at 1·9016 miles, which would be the case were we operating with one mile of line and one ampere. Other conditions remaining the same,

$$x = 1{\cdot}9016\sqrt{\frac{C_1 l}{r_2}}$$

from which the sixth column is calculated.

TABLE B.

Experiments on induction, Gloucester and Berkeley, 10th April, 1887.

Experiment.	Current in primary.	Length of secondary.	Resistance of secondary, including telephone.	Results.
	Ampere.	Miles.	Ohms.	
1	1	1	85	Good.
2	·73	1	85	Somewhat lower than in No. 1.
3	·53	1	85	Slightly lower, but above limit.
4	·33	1	85	Not much distinguishable from No. 3.
5	·22	1	85	Just audible. Taken as limit.
6	·11	1	85	Not a sound.
7	·11	2	112	Faintly heard, but below limit in experiment No. 5.
8	·148	2	112	Somewhat better than No. 7, but still low.
9	·22	2	170	In these experiments the two-mile length was made equal in resistance to twice the mile length, the audible sounds being under these circumstance alike in both wires.
10	·22	1	85	
11	1 0	1	425	Current in primary increased five times, and resistance in secondary in like proportion. Audible limit reached.
12	·44	1	165	Current in primary, and resistance in secondary doubled, and audible limit again reached.
13	·85	1	335	Current in primary, and resistance of secondary increased four times. Limit of audibility again reached.

* The limit of audibility in this case was ·66 mile.

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On April 10th, when the system along the banks of the Severn was again resorted to, as a primary five wires running on the Midland Railway between Gloucester and Stonehouse were bunched at each extremity, and the secondary was one of the road wires which was parallel with the railway, and at an average distance of one mile, over a length of two miles. This secondary could be joined up at will into sections of one and two miles long, the observations being made in the middle. Under these circumstances the observations detailed in Table B were taken.

Having thus obtained the conditions that determine the limit of distance across which induction is perceptible by the telephone, it became necessary to make some careful measurements so as to formulate the law that regulates the observed effects.

Let there be two wires placed parallel to each other for a length l, and at a distance d, then whenever the circuit is made in one wire a secondary current, C_2, due to electro-magnetic induction and in the reverse direction will be produced in the other wire, and when the primary circuit is broken a current in the same direction will appear in the secondary. The relation between the primary, C_1, and induced currents is given by the formula

$$C_2 = MC$$

M being a coefficient of induction depending on—

(1) The length, l.
(2) The distance, d.
(3) The resistance of the secondary circuit, r_2.
(4) The rate at which the primary current rises or falls.
(5) The condition that determines the rate at which the current rises or falls in the secondary circuit.

The following experiments were made to determine these different functions of M. The new General Post Office at St. Martin's-le-Grand is an oblong building, with four convenient corridors or galleries all round the building, along each of which perfectly insulated gutta percha covered copper wires ·050in. in diameter were suspended along the wall. The wires were 20ft. apart, and each formed a complete metallic circuit, 250 yards in length, in which any apparatus could be inserted. The building itself is a huge magnetic field in a constant state of perturbation owing to the concentration there of a thousand circuits conveying messages. The consequence was that each experimental circuit was always in a state of disturbance, rendering accurate measurements during working hours impossible and speech out of the question. Nevertheless, it was quite possible to differentiate the sound of the voice from the rest of the noises though 80ft. of space intervened. It being quite evident that no other instrument than the telephone could indicate these effects, and my object being to measure them in absolute measure two wires were suspended around one corridor at a uniform distance of 6in. apart. After obtaining reading at this distance the space was increased to 12in., and, finally, reduced to a distance of ¼in.

The primary current ·21624 ampere was obtained from a Daniell battery, and was made uniform in strength in all cases. The secondary currents were read by the throws of a Thomson galvanometer. These deflections were reproduced and measured as is done in measuring condensers. The average results of many experiments come out as follows :—

Inch.	Observed.		Calculated.
·25	·004	amperes	·004
6	·000007	,,	·000007
12	·000002	,,	·0000018

It will be seen that the law follows the inverse square of the distance, and this is fully confirmed by previous and subsequent experiments. Moreover, it is easy to show that it must be so when we can neglect the influence of the earth. It is well known, and has been fully verified in all these experiments, that the strength of the secondary current will increase directly with the strength of the primary current, and directly as the length of wire under influence within the limits of these experiments. We can thus calculate a useful standard for use.

250 yards of ·21614 ampere, at 12 inches, induced a secondary current of ·000002 ampere in a circuit of 13·27 ohms, or one mile of one ampere, at one mile distance, would induce a secondary current of ·0000000000013, or 13×10^{-13} ampere; and at two miles 3×10^{-13} ampere in wires such as were experimented with.

We can write the law thus—

$$C_2 = \frac{C_1 l}{d^2 r_2} \times M$$

I intend to repeat these experiments with care to obtain the value of the constant M in C.-G.-S. units. M = ·005.

The disturbances due to the mixed working currents on our telegraphs cannot be appreciable beyond 450ft., but those employed in distributing electric light by means of secondary generators must extend to miles unless they are neutralised by the two conductors being fixed parallel and close to each other.

I have not yet been able to make any experiments to determine satisfactorily the influence of retardation and electro-magnetic inertia on this limiting distance.

I erected two wires of iron for a mile alongside the copper wires, but was not able to get any conclusive results. It is, however, quite certain that there is a difference in the effect when the wires are of iron or of copper, and that the distance across which induction is perceptible must reach a limit of length when the resistance and capacity reduce the rate at which the currents rise and fall, and the effects must begin to diminish. Hence the disturbing effects due to short lines are more pronounced than those due to long lines.

This limit of audibility enables us to calculate the current required by a Bell telephone like that used in these experiments, to become audible. It is roughly the six ten thousand millionth of a milliampere, or in figures ·0000000000006 ampere, or 6×10^{-13} ampere.

Hence the air telegraphs used in America by Edison, Phelps and others for communication with passing trains are readily comprehended, and the distances to which disturbances are propagated between telegraphic, electric lighting, tramway circuits easily calculated. The distance through which communication can be maintained between ship and ship, between lightship and shore, between islands and the mainland, between the defenders inside and those outside a beleagursd city, becomes simply a question of calculation. I have been assisted in carrying out these experiments by Mr. J. B. Chapman, of my own office; by Mr. J. Gavey, of Cardiff, and Mr. J. R. Edwards, of Liverpool, both members of the Society of Telegraph-Engineers, and the Post Office engineers in charge of the districts affected, all of them careful and reliable experimenters

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DISCUSSION.

Sir WILLIAM THOMSON said that a current of an ampere produced in one wire produced a certain current in the other, and he wished to know whether that was caused by the sudden stoppage of it.

Mr. PREECE said the prime currents used in all the experiments were intermittent currents of the duration of $\frac{1}{125}$th of a second.

Sir WILLIAM THOMSON: Equal time off and on?

Mr PREECE: Yes

Sir WILLIAM THOMSON distinctly understood that 6 times 10^{13} was the mean square of the current.

Mr. PREECE: That is so.

Sir WILLIAM THOMSON: There is one ampere broken 250 times per second—that is to say, there are 250 periods or breaks per second?

Mr. PREECE: Yes. I did not use reversals in this instance because they were so extremely difficult to calculate and measure, but I used simply vibrations. There were 250 distinct intermittences in the primary currents.

Sir WILLIAM THOMSON: It is an exceedingly important result, and leads the theory to very correct measurements. Was the result obtained by measurement or theory?

Mr. PREECE: By calculation. The measurements by which the calculations were made were upon the squares at a 4in., 6in., and 12in. distance, and from measurements we made to verify these at 15ft. distance, and also upon the limit of audibility obtained. Others were obtained at a distance of nearly two miles, so that the range is very great. The measurements made at 6in. and 12in. are accurate measurements of the current. They were verified by the measurements between two squares 15ft. apart, and this current is estimated from the previous measurements made and on the limit of audibility at a distance of 1·9 mile, so we know that at 1·9 mile we just lose audibility in the telephone. Just inside the distance—say 1·6 mile—we are well within the point of audibility.

Sir WILLIAM THOMSON: It is not necessary for me to say anything on the excessive importance of these researches, and the applications which

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Mr. Preece has suggested for them. It seemed as if the telephone had solved the problem of telegraphy without wires, but it is exceedingly interesting and important to think that messages can be heard at a mile without any wire whatever connecting the two stations, and I think Mr. Preece deserves our best thanks for having brought this subject before us, and I am sure we all wish to hear more about it. It is a most excellent thing for science that Mr. Preece has taken advantage of the opportunities he has for experimenting on so large a scale, and I hope he will be induced to go on more and more, and give us still further results, which cannot but be valuable in practice besides being exceedingly interesting to science.

REPORT OF THE ELECTROLYSIS COMMITTEE OF THE BRITISH ASSOCIATION.*

In laying before the section this report of the Committee appointed by Sections A and B to consider the subject of Electrolysis in its physical and chemical bearings, I should first say that whereas the main lines of the report have been approved and ordered by the committee, the details and wording have not yet received final sanction, so that if the first person singular should accidentally occur in places where it ought not, it is to be understood that the real official report is that which will appear in the annual volume of the Association, and that the present is to be regarded as merely a general outline of that report.

Work has been carried on during the past year by several members of the committee; and nearly all the questions issued after the Aberdeen meeting by the secretary have been in some shape or other attacked.

The first, On the Accuracy of Ohm's Law in Electrolytes, by Prof. FitzGerald and Mr. Trouton, who reported last year and will make a further report to-day.

The second, On Conduction in Semi-Insulators, by Prof. J. J. Thomson and Mr. Newall. See the *Proceedings* of the Royal Society, No. 256, 1887.

On the third question, the Mode of Conduction of Alloys, Prof. Roberts-Austen will inform us of his experiments to-day.

Mr. Shelford Bidwell has experimented on the subject of the fourth question, concerning the Transparency of Electrolytes.

The sixth, seventh, and eighth, On the Velocity of Ions, are being worked at by the Secretary.

Concerning the ninth we have heard from Mr. J. Brown of Belfast, and on the tenth we have had a letter from Prof. Willard Gibbs.

In order to enable the members of so large a committee to work with some knowledge of what each other is doing, and also to keep up a general intercommunication and interest in the subject, it has been thought desirable and proper to spend a certain portion of the sum granted to the committee in printing and postage. Periodical circulars have been sent among the members and to a few outsiders likely to be interested, and these have been the means of drawing out one or two communications of very distinct interest and value.

It is felt that such informal reports of discussion and free circulation of provisional communications are sufficiently useful to justify the committee in continuing the practice, which was begun as an experiment, and they accordingly are asking for reappointment, with another grant of £50, of which not more than £20 is to be spent in printing and postage.

Your committee feel that the expenditure of a small sum such as this has acted, and may be expected to act, as a trigger capable of liberating in useful directions a considerable amount of energy which otherwise might have remained potential.

There are several moot points at present more or less under discussion within the committee, and I am instructed to lay them before this meeting with the object of eliciting some opinions, suggestions, or information.

First I may instance the obvious question whether electrolytic conduction and metallic conduction are sharply separated off from one another by a line of demarcation, so that no substance distinctly possessing one also possesses a trace of the other.

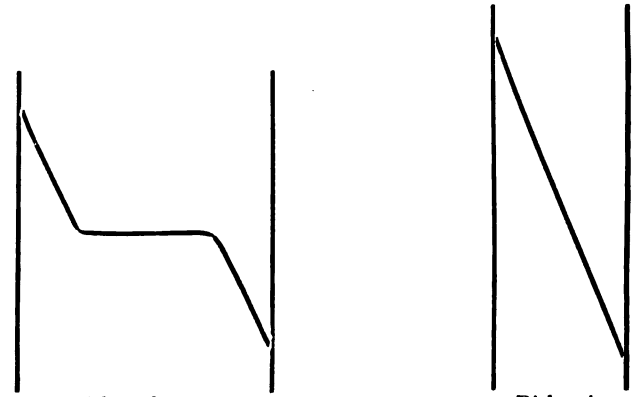
Certain contributions by von Helmholtz, among which we must reckon one on our list for to-day, lead one to believe that the conduction of ordinary electrolytes is *purely* electrolytic, and that no trace of current slips through them without carrying the atoms with it, *i.e.*, without effecting incipient decomposition.

A contribution expected from Prof. Roberts-Austen may perhaps answer the opposite question, viz., whether any ordinary metallic alloy can conduct in the least electrolytically—*i.e.*, whether a well-marked metallic alloy or quasi-compound can be in the slightest degree electrolysed by an exceedingly intense electric current.

Supposing both these questions answered in the simplest manner, viz., in the negative, there must surely remain a group of bodies on the borderland between alloys proper and electrolytes proper, among which some shading off of properties, some gradual change from wholly metallic to wholly electrolytic conduction is to be looked for. Until all such bodies as are tractable to experiment have been cautiously and strenuously examined, we are unable to say whether there is a hard and fast line between the two modes of conduction, or in what manner the gradation from one to the other occurs.

That is the first question. A second concerns the very vital point whether an electric current actually decomposes or tears asunder the molecules of a liquid through which it passes; or whether it finds a certain number of them already torn asunder or dissociated into their atoms by chemical, or at any rate non-electrical, means, and that these loose and wandering atoms thus fall an easy prey to the guiding tendency of the electric slope, and join unresistingly one or other of two processions towards either electrode, only at the last moment attempting a brief and unavailing struggle, when the electrode suddenly looms foreign and forbidding across a molecular distance of 10^{-8} centimetres.

One mode of regarding the facts is to say that across this molecular range of 10^{-8} the electrical forces *are* competent to tear atoms asunder. The E.M.F. of a volt or so can be shown by calculation to be able to do this, so that the difference between an electrolyte and a dielectric may be typified diagrammatically thus:—



The two vertical lines are electrodes, the slant or broken line represents the kind of slope of potential in the two cases respectively.

Prof. Schuster has now discovered one way in which dielectrics shade off into electrolytes; for he finds that in the neighbourhood of an electric discharge rarefied gases are able to conduct as electrolytically as liquids themselves. This discovery that the atoms of gases possess atomic charge as well as those of liquids, if confirmed by further research, is one of considerable interest.

But why do we assert the horizontality of the line of slope in the fluid? Why do physicists feel constrained to assert that no internal static electric stress is possible in the interior of a mass of fluid? The question is but the paraphrase of another. Why do we believe liquids to obey quite accurately Ohm's law for very minute forces? On this head we have direct experimental evidence by Prof. FitzGerald and Mr. Trouton, and less direct but equally conclusive evidence from von Helmholtz. Whether the evidence is perfect and thorough is doubtless a debateable point, but this much is not debateable: it is out of the question to assert that liquids obey Ohm's law and at the same time to assert the existence of a finite electrostatic stress in the interior of a fluid. In other words, however chemists are able to explain the fact of unresisting atomic processions through the liquid—whether by actual procession of individuals or by continual directed interchange—they will be rigorously driven to some form of such doctrine as soon as they accept the evidence for the accuracy of Ohm's law in electrolytic conduction.*

We all know that this doctrine of non-resistance is in some shape or another the old Williamson-Clausius hypothesis, which was based on then newly known facts concerning dissociation.

It would appear, however, that some chemists demur to the existence of a constant average of dissociation among the molecules of a liquid; and it behoves us of Section A to receive their scruples with great respect, being, we may suppose, based upon intimate familiarity with all manner of circumstances and reactions of which we physicists are only superficially cognisant.

But there are ways of picturing all that is necessary to free atomic interchange without postulating actual and constant dissociation. A *potential* dissociation will be granted, sufficient for all purposes, provided chemists admit the probability of a frequent

* As read by Dr. Oliver Lodge before the joint sitting of Sections A and B, on Saturday, September 3rd, 1887, at Manchester. Sir William Thomson in the chair.

* *Note added later.*—This sentence may have to be modified in the final Report, because at the meeting Prof. G. F. FitzGerald made some interesting observations of a controversial character respecting it: and his remarks need to be carefully considered.—O. L.

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interchange of atoms among the molecules of an electrolyte going on always before any E.M.F. has been applied.

Concerning this or other mode in which electrolytic conduction takes place we may congratulate ourselves on the presence here of Prof. Quincke and Prof. Wiedemann, and we hope to hear something from them. The experiments of Dr. Gladstone, and also some unpublished ones of Prof. J. J. Thomson communicated to the committee in a letter, will probably be found to have a bearing on this point.

The question whether there is any radical distinction to be drawn between ordinary compounds and so-called molecular compounds appears to be an open one. Various physical facts lead one to suppose that whereas the ordinary forces of chemical affinity are strictly electrical there may be other non-electrical forces as well, and that such compounds as are held together by these latter forces are intractable to electrical influence. It is difficult for physicists to understand certain facts without the hypothesis of some non-electrical forces between atoms; but on such a subject as this chemists are likely to have in their hands evidence which, if at all decided and distinct, would be entitled to very great weight.

The subject of the partition of the current among different electrolytes when mixed together, and the question of the part the solvent plays in the conduction, seem scarcely suitable for discussion at the present stage, because they only require a few rigorous experiments on lines already laid down to settle them. But I may just say that whereas at a former meeting I thought I had obtained experimental evidence that the water conducted some fourth part of the current in certain solutions, I have since found that, using purer substances, and taking extreme care to avoid loss of weight by spray, which source of loss is very subtle, this evidence puts on another complexion; and at the present time I am disposed to coincide more cordially with the orthodox view, that water conducts almost as little when forming part of a solution as when existing alone. Further experimental evidence is still being obtained, however, and perhaps Mr. Shaw has something to communicate on this head.

Among several communications received by the committee from non-British philosophers is an exceedingly suggestive one by Prof. Willard Gibbs, which raises a very interesting point.

It is perfectly well known that in 1851 our present chairman, Sir William Thomson, reasoning from some experiments of Joule, taught us how to calculate the E.M.F. of a cell from thermo-chemical data,

$$E = \Sigma(J\varepsilon\theta);$$

or

$$\frac{\Sigma\theta''}{46000} \text{ volts.}$$

Strictly speaking he hedged with regard to reversible heat effects in a way equivalent to the complete equation

$$E = \Sigma(J\varepsilon\theta) - \Sigma(J\Pi) \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where Π_1 is the heat developed at junction 1 per unit quantity of electricity conveyed across it, Π_2 the same at the second junction, and so on.

But the value of Π, in any given case, is extremely difficult to measure, especially at metal-liquid and liquid-liquid junctions. Bouty has attempted it with but small success.

Fortunately Helmholtz has thought of applying the second law of thermodynamics to the subject, and shown that it was only necessary to know the rate at which the E.M.F. of a cell varied with temperature in order to know the sum of the Π. For, quite analogous to Prof. James Thomson's freezing point relation

$$dp\,\delta v = J\frac{dT}{T}L,$$

is the following E.M.F. relation:—

$$dE\,\delta Q = J\frac{dT}{T}\delta H,$$

or

$$\Sigma\Pi = \frac{\delta H}{\delta Q} = \frac{T\,dE}{J\,dT} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Putting the two equations together we get

$$E = JT\varepsilon\int\frac{\theta\,dT}{T^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

which we may say is certainly true.

But now Prof. Willard Gibbs suggests a novel mode of applying the second law or doctrine of entropy.

He takes into account the temperature of dissociation, or temperature at which the reaction could reversibly take place; and, calling this T_0, he writes the E.M.F. at any actual temperature T thus:—

$$E = J\theta\varepsilon\frac{T_0 - T}{T_0} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This he gives as the complete expression; wherein, therefore, $J\theta\varepsilon$ is the chemical portion of the total E.M.F., and $J\theta\varepsilon\frac{T}{T_0}$ the thermal portion of the whole E.M.F., equal to $J\Sigma\Pi$.

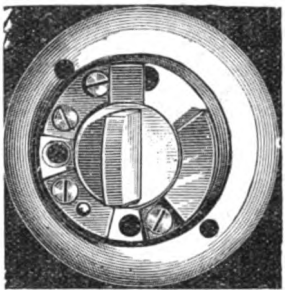
If this were a correct mode of regarding the matter, it would be of the highest interest to be able to calculate dissociation temperature in this way. Unfortunately, several of the best judges in this country have expressed to the committee their serious doubts as to the validity of thus stepping, unguided, outside the region of safe knowledge, across the great gap separating ordinary from dissociation temperatures. We wish Prof. Willard Gibbs were here to support and strengthen his position.

These are the main problems at present under discussion among the members of the committee, and with this summary of them and reference to such of to-day's papers as seem likely to contribute towards their solution the report proper may be understood to close.

I think, however, I am only expressing the feeling of the committee if I say that they view this joint sitting of Sections A and B with great interest, and with the anticipation and hope that it may be the precursor of many other such gatherings during the era of development in the borderland of chemistry and physics which in many directions they feel to be now imminent.

CHINA SWITCHES.

We have received from Messrs. Fowler, Lancaster and Co. specimens of switches which they manufacture, the external parts of which are made of china ware. These switches are made in a variety of forms and sizes, each one of which is supposed to have its special purpose. The accompanying illustration will show one of the forms, and we can say that contact is broken with great rapidity, obviating the destruction of the switch from sparking. The china ware at the back of this particular specimen, and in most of them, has a circular groove, so that when fastened to the wall none of the metal used in the lamp can—unless it is wilfully done—come into contact with the wall.



We are glad to see that china ware is coming into such extensive use for this particular apparatus in the electrical industry. It can be made in all colours, and possesses the very great advantage of being easily kept clean. These may be termed æsthetic advantages. We have not dwelt upon the matter as to the value of the material as regards its electrical properties, these being so well known. This firm also use china ware for connectors, for lamp holders, and for fuses. The workmanship of all the specimens we have seen is excellent.

AMERICAN NATIONAL ELECTRIC LIGHT ASSOCIATION: THE ELECTRIC LIGHT OUTFIT OF THE NEW CRUISERS.

BY LIEUT. J. B. MURDOCH, U.S.N.

The question of how to best install the electric lights in the new men-of-war has been considered in detail, and it seemed advisable to bring the matter before the National Electric Light Association, that the manufacturers of the country might have the problem presented to their consideration in advance of the time when they would be asked to act upon it. In conversation with managers of various companies it has been impressed on my mind that the peculiar conditions existing on shipboard are but imperfectly understood, and as a natural consequence they have not as yet been as satisfactorily met in this country as abroad. I am confident that American ingenuity and skill can fully meet our requirements, and hope that the number of dynamos, about sixty, which will be needed for the vessels already authorised by Congress, may be considered as meriting the experiments necessary for their successful installation.

I am authorised to present in a general way the views of the Bureau of Ordnance of the Navy Department, on the peculiar conditions to be met, and on the best method of meeting them.

In men-of-war the prime requirements of all kinds of apparatus are compactness and lightness. Neither of these is of any material consequence in electric light installations on shore, and both are generally

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ignored. Attention has there been given mainly to the question of efficiency of conversion, and a glance at the advertising columns of any of the electrical journals shows that the maximum efficiency and best system of electric lighting is possessed by each of a dozen companies. Our conditions, so far as the dynamo is concerned, may be summarised as wishing the greatest electrical output for a given weight and bulk, and although at first thought this may seem to be essentially the same thing as efficiency of conversion, it is widely different.

The following figures of well-known American dynamos illustrate this point. The comparison is made on the basis of "watts of output per pound of dynamo." The weight, speed, and electrical output have been obtained in general from the manufacturers, and are given, of course, only approximately. In this comparison it is of course necessary to consider also the sizes and the number of revolutions, the watts per pound increasing with large machines and high velocity.

Dynamo.	Revolutions.	Watts in External Circuit.	Watts per pound.
Edison No. 20	800	50·000	6 0
Brush, H. 3	850	66·000	9·4
American 50 Light	875	21·600	5·7
Westinghouse, No. 18.....	900	30·000	5·4
Hochhausen, No. 8	1,000	35·200	8 8
Mather, 500 Lights	1,050	35·250	7·4
Weston, 6 W. I.	1,050	11·500	4·1
Brush, G. 4	1,050	28·300	9·3
American, 15 Light. Hie. ...	1,075	6·480	4·8
Weston, 7 W. I.	1,100	20·125	6·5
Westinghouse, No. 12.....	1,100	18·000	4·
Brush, F. 5	1,100	19·000	8·5
Thomson-Houston, H. I. ...	1,150	25·600	6·1
Edison, No. 12	1,200	30·000	6·9
Hochhausen, No. 6	1,200	17·600	8·
Thomson-Houston, E. I. ...	1,250	13·200	5 8
Mather, 400 Lights	1,300	28·100	7 0
Edison, No. 8	1,400	20·000	6·9
Thomson-Houston, C. I.....	1,500	6·000	5·6

The next consideration is that of the connection of the dynamo to its engine, and a starting point is afforded in the rule that belting should never be used on a sea going vessel. Nothing so radically violates our condition of economy of space as the use of belting. When space is saved by the use of a short belt, the working conditions are comparatively unsatisfactory. Belts are liable to be thrown off by the sudden change of load to which our dynamos are subject, and become a source of danger to the attendants if the ship is rolling heavily. The adoption of fixture gearing between engine and dynamo has been suggested, and is probably practicable, but its durability on shipboard, when the motion of the vessel must cause working of the two shafts, may not be great. In the navies of Europe the practice of direct connection is universal, the dynamo shaft being coupled to that of the engine. This calls, of course, for either a great reduction of the speed of the dynamo or a corresponding increase of that of the engine. It is easy enough to procure an engine running 1,500 revolutions per minute, but it is a very different matter to find one which will govern satisfactorily at so high a speed. So far as I can ascertain there is no automatic engine manufactured in the United States capable of indicating 30 horse-power which is designed for a higher speed than 500. I have been informed, however, that some of the types now in the market could be modified so as to operate well at 500. I am not aware of any dynamo in the United States absorbing 30 horse-power, which would yield its normal output at even the higher speed. It is much easier to reduce the speed of the dynamo while preserving its electrical output than to raise the speed of the engine. Admitting the desirability of direct connection on shipboard, the problem proposed is the best method of obtaining the same outpnt in watts per pound, at speed below 500, that is now commonly obtained between 1,000 and 1,500.

Dynamo.	Revolutions.	Watts in External Circuits.	Watts per pound.
Manchester, No. 6	350	9·000	3 6
Victoria, H. 3	350	36·000	9·7
Siemens and Halske.....	350	16·000	8·1
Edison-Hopkinson, 10 in L...	350	16·800	2·9
Manchester, No. 7	400	22·500	4·6
Victoria, F. 3	400	21·600	8·6
Siemens and Halske.....	400	20·000	10·2
Edison-Hopkinson, 15 in S...	420	39·600	3·4
Gramme, H. 2 d 225	450	23·600	8·3
Elwell-Parker	450	50·000	5 6
Crampton, $\frac{40}{110}$ J.	460	45·100	6·7
Edison-Hopkinson, 8 in L....	525	15·400	3·3
Manchester, No. 5	525	6·500	4·7
Crompton, $\frac{32}{110}$ J.....	550	24·750	6·0
Manchester, No. 6 A	550	25·000	6·75
Edison-Hopkinson, 10 in L...	550	25·200	4·4
Victoria, D. 2 S.	600	8·400	6·7
Gramme, H. I. c 200	600	14·000	6·4
Ganz	670	50·400	9·2
Crampton, $\frac{40}{110}$ J.....	675	66·000	9·8
Goolden-Trotter	765	16·000	6·2

The preceding figures of European dynamos, obtained in same way as those already given for American machines, and probably equally accurate, will show how this problem has been met abroad.

It is necessary to only refer incidentally to a few of the methods by which these results have been obtained. The principles are the elimination of all iron not needed for the magnetic circuits of the dynamo, and the adoption of a type in which this circuit furnishes a framework of necessary rigidity. The magnet core should be of the best wrought iron, this single condition frequently reducing the weights 25 per cent., while preserving the output. Armatures of large diameter give high perpetual velocity at low speed, and this seems to recommend the Gramme ring, a large drum armature being cumbersome. The Gramme form has another advantage for ship's use, that it can be repaired or even rewound with the facilities existing on shipboard, although I believe a Siemens winding has recently been perfected which admits of equal facility of repairs. The use of multipolar machines contributes to lightness, and the Siemens and Halske machine referred to in the preceding table has fine field-magnets inside a Gramme ring. Flattened ring armatures and multipolar magnets also give large output for the weight.

Every ship aboard which the electric light is a necessity should have two similar dynamos, that either may be used as well. At present this precaution is not observed in the navy. The lighting of the ship by incandescent lamps is under the control of the Bureau of Navigation, and the installation for this purpose consists of an ordinary plant of an engine driving a dynamo by belting. The electric search lights, two of which are furnished to each large vessel, are supplied by the Bureau of Ordnance, the installation for this purpose consisting of a Brotherton engine driving two C Grammes, connected direct on the same bed plate. In case of accident, the incandescent dynamo will not work the search lights to advantage, nor will the Grammes operate the incandescent lights well. This is of course most unsatisfactory, and the need of the service is for a dynamo which will perform either work well, and, if necessary, both at once.

Our search lights require about 50 volts and 50 amperes for ordinary work, the current being sometimes increased to 100. The lamp is operated by hand in order to fully utilise the radiation from the crater of the positive carbon. The hand lamp and Mangin Projector are in use in nearly every navy in the world for projecting a condensed train of lights to a distance. Automatic lamps do not admit of continuous adjustments as readily as the hand lamp, and are not so thoroughly under the control of the operator. In any search lights the arc may sometimes fail, and it is sometimes advisable to cut the lights out without notice. Large and sudden variations of load are thus liable to occur, and these should not affect the dynamo. It is unquestionable that incandescent lights can be worked from a series dynamo, and search lights operated by a shunt machine, but most of these proceedings are makeshifts. It is undeniable that both search lights and incandescent lights can be worked satisfactorily by a compound dynamo. I have been called upon to work all these kinds of dynamos for each purpose, and the compound dynamo works incandescent lights as well as a shunt machine, and search lights better than does the series machine supplied for the purpose. I have also worked two search lights and fifty incandescent lights simultaneously from one compound dynamo. Each search light had $\frac{3}{10}$ of an ohm dead resistance in circuit to bring the difference of potential down to about 50 volts. There is nothing new in this, but I have so frequently been asked what advantage the compound dynamo possessed that I have trespassed somewhat on the time of the Convention to give reasons for the opinion that all naval dynamos should be compound wound for a constant potential.

It is probable that many fine new vessels will require electric motors. Some of our gun carriages may be worked in this way, on account of the advantages that an electric motor offers in small weight and bulk, and in the important fact that it is so much easier to splice a broken main than to patch a leaky pipe when steam or compressed air is used for power. Electric motors will be useful for shell hoists and ammunition whips, reducing the number of men employed for these purposes. Here, also, light weight and compactness are absolutely essential, and nine-tenths of the motors in commercial use would be barred out as too heavy. A 10 horse-power motor, the largest we would probably use, should not weigh over 500lbs.

The potential at which the main should be kept must be determined from the relative importance of the three uses to which our dynamos will be put. As we are not bothered by the question of long distance transmission, we can well use a low potential for incandescent lights and motors, while search lights require only 50 volts, although it is advantageous with any dynamo to have a little dead resistance in the search light circuit. For these reasons I think 70 volts is about the best point for a compromise. This is the voltage used in the French navy, the English working at 80. If 10 search lights can be successively worked in series, the potential at the dynamo might advantageously be raised to 110, or even 120 volts. Experiments have been made to test this point, but we are not decided as yet. Should there, however, be any material advantages secured in the working of either incandescent lights or motors by the use of a high potential, the search lights could be operated with sufficient resistance to give them their proper potential.

The same requirements of small bulk and weight must control in the choice of engines. The adoption of a compound dynamo throws extra responsibility on the engine, as without constant speed the advantages of the dynamo are not apparent. American automatic engines can easily meet this demand, but most of them are too heavy, rigidity of frame being unnecessarily large masses of cast iron. 100lbs. weight per indicated horse-power, with 80lbs. steam, is a liberal allowance. In many European engines, steel and phosphor bronze have been largely used to obtain lightness.

It may be interesting to compare a few well-known dynamos as to com-

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pactness, the comparison being made on watts of output per square inch of floor space.

Dynamo.	Revolutions.	Watts in External Circuits.	Watts per square inch floor space.
Manchester, No. 6	350	9·000	4·9
Edison-Hopkinson, 10 in L...	350	16·800	6 9
Manchester, No. 7	400	22 500	6·0
Edison-Hopkinson, 15 in S...	420	39·600	9·1
Crompton, $\frac{1}{10}$ J.	460	45·100	20·3
Edison-Hopkinson, 8 in L...	525	15·400	6·5
Manchester, No. 5	525	6·500	4·6
Ganz	670	50·400	20·9
Crompton, $\frac{6}{10}$ J.	675	66·000	25·4
Edison, No. 20	800	50·000	8·8
Brush, H³	850	66 000	23·5
Westinghouse, No. 18	900	30 000	5·8
Hochhausen, No. 8	1,000	35·200	15·0
Mather, 500 Light	1,050	35·250	8 5
Weston, 6 W. I.	1,050	11·500	4·4
Brush, G⁴	1,050	28 300	17·7
Weston, 7 W. I.	1,100	20·125	5·4
Westinghouse, No. 12	1,100	18·000	4·7
Brush, F. 5	1,100	19·000	15·3
Thomson-Houston, H. I.	1,150	25·600	9·0
Edison, No. 12	1,200	30·000	7·7
Hochhausen, No. 6	1,200	17·600	13·3
Thomson-Houston, E. I.	1,250	13·200	8·2
Mather, 400 Light	1,300	28·100	7 3
Edison, No. 8	1,400	20·000	6 0
Thomson-Houston, C. I.	1,500	6·000	5·9

As illustrating the advantages of direct connection in economy of floor space and also of weights when care is taken, I have a few statistics of ship installations:—

	PLANT.	Connection.	Total Weight.	Floor Space.	Weight per 16c. Lamps.	Floor Space per 16c. Lamps.
				Sq.ft.		Sq.in.
U.S. Steamer "Chicago"	2 Edison No. 8 (200 l'ghts).. 2 Armington and Sims	Belting	16·000		40	
U.S. Steamer "Boston"	1 Brush Compound (150 lts.) 1 Straight Line	Belting	10·400		70	
U.S. Steamer "Atlanta"	1 Weston 7 W. I. (150 lights) 1 Armington and Sims	Belting	6·500	105	43	101
Steam Yacht "Alva"	1 Siemens' Compound (160 lights) ..... 1 Wilians' Engine	Direct 450 Rvs.	8·700	27	43	24
French Ironclad "Indomptable"	2 Plants each ..... 1 Multiplex Gramme(160 lts.) 1 Vertical Compound Engine	Direct 350 Rvs.	7·040	29	44	26
Torpedo Station	1 Brush No. 7 Special (100 lts.) 1 Westinghouse	Direct 700 Rvs.	4·000	17	40	25
Torpedo Station	1 Weston No. 8 Special (270 lights) ..... 1 Westinghouse Automatic .	Direct 390 Rvs.	9·300	75	42	41

The preceding show a general average of about 40lbs. dead weight of dynamo and engine for each 16-candle lamp, whether high or low speed dynamos are used. In the following, special attention has been paid to the manufacture of light and compact apparatus:—

	PLANT.	Connection.	Total Weight.	Floor Space.	Weight per 16c. Lamps.	Floor Space per 16c. Lamps.
				Sq.ft.		Sq.in.
	1 200-Light Brush Compound 1·8in. Brotherhood	Direct	5,500		27½	
Steam Yacht "Beatless"	1 Arnold Dynamo (30 lights) 1 Vertical Engine	Friction	600	6	20	29
	1 Goolden-Trotter Dynamo (75 lights)..... 1 Tower Engine	Direct	900	5½	12	11
	1 Victoria Dynamo (60 lts.) 1 Brotherhood	Direct 765 Rvs.	800	4⅞	13	11
Italian Cruiser "Dugali,"	1 Parson's Dynamo (150 lts.) 1 Parson's Steam Turbine ..	Direct 9,000 Rvs.	900	6½	6	6
	(3 plants like above.)					

It is noticeable abroad that with the type of slow speed dynamos established in the markets the system of direct connection is adopted in many isolated plants on shore. The tendency throughout Europe is to reduce the speed of dynamos, preserving the electrical output by a careful study of details. Few recent machines built abroad are designed for higher speed than 800, while an American company operating at and above 850 advertises slow speed as one of the advantages of its dynamos.

In this country the naval demand for slow speed dynamos will be comparatively small, but if it serves to introduce the type into the market I am satisfied from what has taken place in Europe that the system of direct connection will create a field for itself, as soon as the apparatus can be procured without the heavy expense attendant on special work. It recommends itself in any installation where either weight or floor space is to be economised. I believe it can be successfully utilised in lighting railway trains, especially if, in the near future, railroad companies have to furnish steam for heating purposes. Plants could be furnished small steamers and yachts in which a common installation could not find room.

There are one or two other considerations governing ships' installations. The principal is the absolute necessity of high insulation. The Bureau of Navigation has, in its recent contracts, called for an insulative resistance of 1,000 megohms per nautical mile, after twenty-four hours immersion in salt water.

That covering is also required as a protective against mechanical injury. We are so exposed to short-circuiting and corrosion from salt water that the high standard called for is most wise. All switches, junctions, and safety boxes, and in fact all parts of the circuit should be thoroughly insulated. Difficulty has been experienced from salt water running along the wires into lamp sockets short-circuiting the lamps. The insulation of the whole circuit is sometimes required to be at least 1,000 ohms for each volt at the terminals of the dynamo.

COMPANIES' MEETINGS.

The Direct Spanish Telegraph Company (Limited).

The 28th ordinary general meeting of the shareholders of this Company was held on the 30th ult. at Winchester House, Old Broad-street, under the presidency of Sir James Anderson.

The MANAGER (Mr. C. Gerhardi) read the notice convening the meeting and the minutes of the last meeting, which were signed by the Chairman as correctly entered.

The report and accounts were taken as read.

The CHAIRMAN: Gentlemen, before moving the adoption of the report I shall, as usual, make such remarks as I think may interest you. You will remember, I daresay, that we promised when the new scheme for the readjustment of our capital was carried out, that we would probably give you a dividend of 2 per cent. The report will show you that we are now in a position to declare a dividend at the rate of 2½ per cent. In the remarks I made at the last meeting I notice I held out the prospect that there might be 4 per cent. for the year, and had the traffic continued throughout as it was then we should inevitably have given you 4 per cent., but immediately after our meeting we came upon what we call the bad half-year, and the traffic went down, and continued low until about three months ago. I still hope as that was our bad half-year and this is now our good one—and we have already earned upwards of £670 more for the three months of this half-year than we did for the corresponding period of last year—that we may partly redeem our promise. We are working, as you know, at a reduced tariff, and it will interest you to know that to earn the £367 referred to in paragraph 2 of the report we have had to carry 180,000 words in excess of what we carried in the previous half-year, and the expense of earning that £367 over that of the previous half-year was £72. This half-year we are, for the three months that have gone by, £670 to the good, and I look forward, when we next meet you, to declaring a dividend that will make up at least 3 per cent. for the year. This is all we know and all we can know. It is true that the dividend is a very modest one—too modest for a submarine telegraph property. I have before remarked at these meetings, I think, that any telegraph company that can earn a dividend when forced down to a minimum tariff—that is, a tariff below which we hardly look to be forced hereafter, or, at any rate, for a very long time—any telegraph company that can pay a small dividend at such a low tariff is to be congratulated, because I think the days have gone by for high tariffs. The Press, different Governments, and rival companies are all forcing us down, and are determined that we shall not, if possible, make a living. Therefore, to get to a dividend-earning position at a tariff so much reduced is to my mind not altogether unsatisfactory. Besides, in this Direct Spanish Company we have the elements of life and growth. All the growth we have had this half-year since we became a living concern has been due to commerce. No king has died, no prince has been born, and no political complication has arisen to make our revenue greater than it would be under normal conditions. It seems to us, as far as we can examine it, to be a fair development of commercial trade. I therefore think that we are not taking too sanguine a view when we look forward to a steady growth in our revenue. At the same time I must remind you, as I am constantly reminding myself, that unless we have a good large reserve I look with grave misgivings on telegraph property; but, as you will see, we have not trenched upon the £3,000 odd we had in hand when we readjusted our capital, and we have carried forward the full reserve that we held to be necessary when we put the plan before the proprietors and the law courts. So far our revenue, such as it is, has enabled us to do that, and for the first time, I think, for five years, to pay a dividend on our ordinary shares, and that is so far very satisfactory. I do not know that the accounts call for any special remarks. It is a very small report, and it is a small revenue, and does not admit of many remarks. I hope our lines will continue in good order. If they continue in the condition they

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are in now I look forward to the Direct Spanish Company becoming as good an investment as submarine telegraph companies can be. With these remarks I beg to move "That the report and accounts now presented be, and are hereby, received and adopted."

Mr. EDMUND ETLINGER seconded the motion.

Mr. DAVID LOWE asked whether there was any chance of a cable connection being made between Carthagena and Malta.

The CHAIRMAN said he did not despair of it, but whether they would connect at Carthagena or Barcelona was not quite clear.

Mr. LOWE pointed out that the Company had made a loss of £178 in their investments, which he regarded as a somewhat serious item, and suggested whether it would not be as well to redeem their debentures from the Eastern Company by giving them a bonus on those debentures.

The CHAIRMAN: What would you pay the money out of?

Mr. LOWE said he would fall back on the reserve fund of £5,000. He thought it would be to the advantage of the Company to carry out such a scheme.

The CHAIRMAN said that the question was not lost sight of by the Directors, who had another scheme in their mind for dealing with it.

Mr. JOHN NEWTON asked whether the dividend of 2½ per cent. was for the half-year or per annum.

The CHAIRMAN: Per annum.

Mr. BURT pointed out that by a clerical error in the sixth paragraph of the report the words "at the rate of" should have appeared in the preceding line to give the paragraph its full significance.

In reply to a shareholder the CHAIRMAN said that 6 per cent. was paid on the debentures.

The motion was then put and carried unanimously.

The CHAIRMAN next moved and Mr. ETLINGER seconded the following resolution:—"That the preference dividend at the rate of 10 per cent., less income-tax, and a dividend at the rate of 2½ per cent. per annum on the ordinary shares, free of income-tax, be, and are hereby, declared."

The resolution having been carried unanimously, a vote of thanks to the Chairman and Directors, proposed by Mr. D. LOWE and seconded by Mr. W. B. COCHRANE, was cordially agreed to, and the proceedings then terminated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 30th September amounted to £3,981.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of September was 3,069, estimated to produce £2,500, against 2,675 messages, producing £2,272, in the corresponding month of last year. The traffic receipts for the month of June, estimated to produce £2,750, realised £2,929.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of September amounted to £1,990, against £1,767 for the corresponding period of last year.

DIRECT UNITED STATES CABLE COMPANY.—We are informed that the Board of this company have resolved upon the payment of an interim dividend of 2s. per share, free of income tax, being at the rate of 2 per cent. per annum, for the quarter ended 30th ult., such dividend to be payable on and after October 24 next.

EASTERN TELEGRAPH COMPANY.—This company's traffic receipts for the month of September amounted to £46,081, against £40,778 for the corresponding period of 1886.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of September amounted to £36,400, and to £30,107 in the corresponding period of 1886, showing an increase of £6,293.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for September amounted to £23,600. For the period 1st January to 30th September, 1887, they amounted to £197,720. For the corresponding period in 1885 and 1886 the receipts were £217,240 and £195,560 respectively.

SUBMARINE CABLES TRUST.—Notice has been given by the Submarine Cables Trust that the balance of £1. 10s. due on the April coupon will be paid on and after 15th inst. by Messrs. Glynn, Mills and Co., of Lombard-street, between the hours of 10 a.m. and 2 p.m. After making this payment the trustees will have a small balance in hand which, with the income derivable from their investments for the next six months, will, it is estimated, be sufficient to pay the October coupon in full, on April 15, 1888. The April coupons (not those for October) must be left with the bankers five clear days before calling for payment.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this company for the month ended 30th September amounted to £4,450.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The Board of Directors of this company have declared an interim dividend of 3s. 9d. per share (free of income-tax) for the half-year ended 30th June last, being at the rate of 2½ per cent. per annum upon the Ordinary Shares and 5 per cent. per annum on the Preferred Ordinary Shares, payable on the 15th inst.—The traffic receipts of the company for the week ended September 30th, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £2,944.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 30th September are £2,368, as compared with £1,848 in the corresponding period of 1886. The June receipts, estimated at £5,706, realised £5,844.

PERSONAL.—Mr. Trotter writes to us *re* the dissolution of partnership mentioned in our issue of the 30th ult.:—I am much obliged for your notice under this head in to-day's *Electrician*. Mr. Goolden informs me that he has had several inquiries as to the probable prejudicial effect of my retirement on the future of his factory. He thinks that the feeling which prompted these inquiries will be increased by your statement that I designed the Goolden-Trotter dynamos. It has always been my endeavour since I have been a principal to give credit to whom credit is due, and on every occasion on which I have made public statements, either at meetings of the scientific societies or in the technical journals, I have been careful, where the occasion demanded it, to express my indebtedness to my staff, especially to Mr. H. W. Ravenshaw. This gentleman, who has had a thorough training both as a mechanical engineer and as an electrician, has occupied the posts of head draughtsman and assistant manager at this factory. The duties of the former post are well understood by all trained engineers, and I have every reason to expect that as he has assumed the managership of the factory, and that the rest of the draughtsmen, junior engineers, and foremen will continue without change, there is no reason, as you, Sir, observe, why under the future management on the lines already laid down, the business should not continue to command success. It is a pleasure to me to record the high esteem I feel for Mr. Ravenshaw's insight into the design of dynamos, and the instinct which he appears to have acquired through spending day after day among the details of construction and windings. Although it has not been the policy of the late firm to publish to any great extent either the methods of their manufacture or the results of their business, I think that my share of the work is sufficiently known to give weight to my expression of goodwill.

PERSONAL.—We are informed by Mr. Guy C. Fricker that he has commenced business as consulting electrical engineer at No. 12, Delahay-street, Great George-street, Westminster. Mr. Fricker mentions that he is not interested in any patents, nor will he engage in contractors' work. Taken in connection with Mr. Fricker's well-deserved reputation both as a theoretical and a thoroughly practical engineer and electrician, we anticipate that he will find considerable scope for his energies in the capacity of consulting electrical engineer.

THE GAULARD-GIBBS TRANSFORMER.—We understand that the National Company for the Distribution of Electricity by Secondary Generators, Limited (Gaulard and Gibbs system), have concluded arrangements with Messrs. Elwell-Parker (Limited), of Wolverhampton, for the manufacture of their apparatus, and that they have in consequence closed their works in Castle-street. We are also informed that Mr. Charles Moseley, whose sudden death in Manchester we regret to record elsewhere, had arranged to join the Board of the National Company.

REMOVAL.—Notice is given by the Manchester and District Edison Electric Light Company (Limited) that on and after the 6th inst. the address of the company will be 14, St. Ann's-square, and 15, Barton-square, Manchester.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 5.		BUSINESS DONE WEEK ENDING OCT. 5. Highest.		Lowest.	
Anglo-American	36½,	37½	.....	36¾	.....	36½
Do. Preferred	59½,	60½	.....	61	.....	59¾
Do. Deferred	13½,	14½	.....	15	.....	13 5-16
Brazilian Submarine	11,	11¼	.....	11¼	.....	11⅛
Cuba	11⅞,	12¼	.....	12 3 16	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅞,	3¼	.....	—	.....	—
Do. Preference	8½,	9½	.....	—	.....	—
Direct United States Cable	8¾,	9	.....	8 15-16	.....	8¾
Eastern Telegraph	11,	11¼	.....	11¼	.....	11 1-16
Do. 6 per Cent. Preference	14,	14½	.....	14 7-16	.....	—
Do. 5 per Cent. Debentures, 1899	106,	109	.....	—	.....	—
Eastern Extension	11½,	11⅞	.....	11⅞	.....	11 7-16
German Union	10¾,	11	.....	—	.....	—
Globe Telegraph and Trust	5⅜,	5⅝	.....	5½	.....	5 7-16
Do. Preference	13½,	13¾	.....	13¾	.....	13½
Great Northern	13⅜,	14	.....	14	.....	13⅞
Indo-European	36,	38	.....	—	.....	—
Reuter's	7⅞,	8½	.....	8½	.....	—
Submarine	170,	180	.....	178	.....	173
West India and Panama	⅝,	¾	.....	—	.....	—
Do. 1st Preference	9½,	9⅞	.....	—	.....	—
Western Brazilian	7⅞,	8	.....	7⅞	.....	—
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	101,	104	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	.....	—	.....	—
Oriental	5-16	7-16	.....	—	.....	—
United Telephone	11⅞,	12⅛	.....	12 5-16	.....	12
United River Plate	4⅞,	5⅛	.....	—	.....	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2⅛,	2¼	.....	—	.....	—
Do. (fully paid)	3,	4	.....	—	.....	—
Swan	1⅛,	1⅜	.....	1 11-16	.....	—
Maxim Weston	3-16,	5-16	.....	¼	.....	—

MISCELLANEOUS.

Telegraph Construction	37,	38	.....	37½	.....	37
India Rubber, Gutta Percha, and Telegraph Works	21,	22	.....	22	.....	21½

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NOTES.

PERSONAL.—Mr. C. H. W. Biggs has resigned the position connected with this Journal which he has held since its commencement in 1878.

THE LIGHTING OF TRIESTE.—The Municipal Council of Trieste have decided to introduce electric lighting into the town.

THE CHINESE TELEGRAPH AND TELEPHONE SCHEME.—According to yesterday's *Times* the Chinese Government have repudiated the Convention entered into by Li Hung Chang with the American Financial Syndicate.

TELEPHONE TENDERS WANTED.—Tenders are invited by a Royal order in the Madrid *Gazette* for the establishment and working of a telephone service in Salamanca. The adjudication will take place on the 29th of this month.

TENDERS FOR LIGHTING COLWYN BAY. — Tenders are asked by the Local Board for the lighting of Colwyn Bay for three years "either with gas, oil, or electric light." Information may be obtained from the Clerk to the Board, and tenders will be received up to the 18th inst.

THE USE OF SPRINGS ON TELEGRAPH WIRES.—We have received a long letter on the above subject which, however, came too late for insertion in the current issue. Communications containing drawings or photographs for insertion should be in our hands *not later* than by the first post on Wednesday morning.

COURSE OF EXPERIMENTAL LECTURES BY DR. FLEMING.—In another column will be found some particulars of a course of experimental lectures on the practical applications of electricity, which will be given by Dr. Fleming at University College on Friday, at 4 p.m. The course consists of twenty-four lectures.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The first meeting of the Society of Telegraph-Engineers and Electricians for the winter session will be held on 10th November, when a paper will be read "On Deep Sea Soundings in Connection with Submarine Telegraphy," by Mr. E. Stallibrass, F.R.G.S., member.

THE INTERNATIONAL SOCIETY OF ELECTRICIANS AND THE PARIS EXHIBITION OF 1889.—M. Berger, the Director-General of the forthcoming Paris Exhibition has addressed a letter to the President of the International Society of Electricians, requesting the good offices of that body in acting as intermediary for the assistance of foreign exhibitors in the electrical section of the Exhibition.

CHESTERFIELD.—The National Telephone Company are making arrangements for opening a telephone exchange in this town. Chesterfield is at this moment probably the most important town in the country which still remains without telephonic communication. A trunk wire will be run to Nottingham and Sheffield, and not less than 10,000 firms will be brought within hail of the local exchange.

"THE RADIAL DISTRIBUTION OF CURRENTS IN WIRES."—We commend the paper under the above title, which will be found in another column, to the attention of all students who are engaged in grappling with the difficulties of alternating currents. The paper is of a non-mathematical character, and will be found very helpful in giving clearness of conception upon a particular point which is but little understood.

"MODERN VIEWS OF ELECTRICITY."—We would call the attention of our readers to a most valuable and interesting paper under the above title in last week's *Nature* from the pen of Dr. Oliver Lodge. The paper is the revision and expansion of a lecture delivered by Dr. Lodge partly at the London Institution, on January 1st, 1885, and partly at the Midland Institute, Birmingham, November 15th, 1886, but not hitherto published.

THE WOODWARD SECONDARY BATTERY.—A company has recently commenced operations in Michigan for the manufacture of a secondary battery, of which the positive plates are made in the following way:—Molten lead is poured upon common salt or other suitable soluble substance, and the two substances are intimately mixed together. After cooling the salt is washed out, and a porous plate is left, which is filled with peroxide.

TRIAL OF THE ELIESON ELECTRIC BOAT.—Elieson's electric boat, "The Countess," of which we gave a description some months ago, received a second and successful trial on Wednesday last, in the Albert Dock. We may repeat that this boat is 90ft. in length, the screw is 3ft. 6in. in diameter, with a pitch of 5ft. 6in., and runs at 200 revolutions per minute. "The Countess" is thus the largest boat to which electrical propulsion has yet been applied.

TELEGRAPH LINES TO PARIS.—There are in all 43 telegraph lines and cables by which Paris is placed in communication with the other European States. Of these there are 12 lines to this country, 10 to Germany, 3 to Austria, 4 to Belgium, 1 to Denmark, 1 to Spain, 2 to Holland, 6 to Italy, and 4 to Switzerland. There are only ten cities and towns in France which possess more than one line to Paris. These are as follows:—6 to Marseilles, 4 to Bordeaux and Lyons, 3 to Lille, Havre, Brest, and Toulouse, 2 to Amiens, Montpelier, and Nantes.

THE "INTRINSIC LIGHT" OF SOURCES OF ILLUMINATION.—M. D. Monnier defines the intrinsic light (*éclat intrinsique*) of a lamp as the ratio of the photometric power to the illuminating surface. This obviously depends very largely upon the temperature of the source of light. The following figures are given as the intrinsic light of certain lamps:—

Argand burner	0·3	candle per	sq. cm.
Siemens' regenerative burners	0·6	,,	,,
Incandescent lamp.....	30	,,	,,
Arc lamp	480	,,	,,

THE BALTIMORE AND OHIO TELEGRAPH SYSTEM.—The purchase of the Baltimore and Ohio telegraph system by the Western Union Company is at length an accomplished fact. This transaction goes a long way towards giving the Western Union Company the monopoly of the telegraph system of the United States. It is said that the sum paid down amounts to about £800,000, but in addition to this it is agreed to pay a rental which, if capitalised, would amount to very nearly another million sterling. The Western Union directors have authorised the issue of $5,000,000 of stock to provide the necessary funds.

TRAIN LIGHTING EXTRAORDINARY.—We have seldom seen a more remarkable or original notion put forward in a responsible quarter than that contained in a French specification filed by *La Société pour le transport de la force par l'Electricité*, as a method of lighting railway carriages by electricity. This is the company of which M. Marcel Deprez forms so distinguished an ornament. The proposal is to place a small wind-

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mill upon the roof of each carriage, and so to provide motive power for the usual paraphernalia of dynamos, secondary batteries, and glow lamps. As to the prospects of success of this scheme, while of course we shall hope for the best, yet we are prepared—we may say *fully* prepared—for the worst.

THE AMERICAN INSTITUTE ELECTRICAL EXHIBITION.—The Annual Exhibition of the American Institute was opened in New York on the 28th September. Most of the leading manufacturing electrical firms in America are more or less extensively represented. The building is lit by 100 arc lamps of the Ball Electric Company, and 500 incandescent lamps on the Mather system. The historical section has been greatly enriched by loans from the Franklin Institute, the Stevens Institute, and a number of private individuals, and is a large and highly valuable collection. It includes Franklin's original friction electric machine, a piece of the first Morse message, an old Morse printer, Prof. Farmer's first self-exciting dynamo machine, and motors of curious construction.

PERSONAL.—We have much pleasure in inserting the following communication from Messrs. Laing, Wharton and Down. A full account of Mr. Pope's gallant deeds appeared in our columns at the time:—"Sir: You will remember that on the 14th of July our engineer, Mr. Gilbert C. Pope, di-played great courage at Waterford in saving the life of Mr. D. Keogh, and again on the 30th in bringing to shore the body of Mr. Baldwin. These gallant acts were duly represented by us to the Royal Humane Society, and we have now the pleasing task of forwarding to Mr. Pope the certificate and medal which have been awarded to him. We think this may be of interest to some of your readers, and trusting you will find space to record it, we are, yours, &c., Laing, Wharton and Down."

ELECTRO-PLATING WITH ALUMINIUM.—In the *Jewellers' Journal* the following recipe for electro-plating with aluminium is given by Herman Reinbold:—"Fifty parts of alum, $AlK(SO_4)_2 + 12H_2O$ are dissolved in 300 parts of water, and to this 10 parts of chloride of alumina (Al_2Cl_6) are added, heated to 200deg. and cooled, whereupon 39 parts of cyanide of potassium are added. The object to be plated has to be cleaned, and to be absolutely free from grease in any form, whereupon it is suspended in the bath over the electro-positive electrode, the plate of metallic aluminium to be suspended on the negative pole. The electric current ought to be weak. The plating when polished will be found to be equal to the best silver plating, having the advantage of not being oxidised or getting black when brought into contact with sulphurous vapours, which would make it especially valuable for plating spoons and tableware."

WESTON-SUPER-MARE.—A local journal has the following paragraph:—"The unanimous expression of opinion of the meeting held at the Victorial Hall last week in favour of introducing the electric light into Weston-super-Mare has induced initiatory steps for the formation of a local company for supplying the light. It is hoped that Mr. Massingham, of Bath (the originator and managing director of the Taunton Electric Lighting Company), may be induced to accept the position of managing director of the Weston Company, as such an arrangement would relieve the local promoters of a large amount of responsibility, and help to insure the technical and financial success of the undertaking. We understand that the accounts of the Taunton Company for six months ended 30th June last, after making every allowance for depreciation, &c., show a dividend at the rate of 6 per cent. per annum upon the whole of the paid-up share capital."

THE PROJECTED IMPERIAL TRANSPACIFIC CABLE.—A Canadian journal states that the Dominion Government has received an intimation from the Imperial authorities that the British Government cannot undertake the cost of a special survey of the route of the proposed Transpacific cable between British Columbia and New Zealand and Australia unless some guarantee is given that the line will actually be laid. Under these circumstances Mr. Sandford Fleming, who may be looked upon as the father of the intercolonial cable scheme, has suggested to the Hon. Mr. Foster, Minister of Marine and Finance, that the Colonies themselves should undertake the cost of survey, and he proposes that Canada's contribution thereto should be the loan of a vessel. Mr. Foster is favourably impressed with the proposal, and will at once lay the matter before his colleagues. Should the Government decide on accepting the proposal, communications will at once be opened with the different Australian Governments.

TWISTED JOINTS IN TELEPHONE LINES.—It will probably surprise most telegraph and telephone engineers in this country to learn that in the States a distinct preference is now expressed for a twisted over a soldered joint. When the Long-Distance Telephone line between New York and Philadelphia was first projected experiments were carried out in order to test the value of the MacIntire as compared with the Britannia joint. The MacIntire joint is thus briefly described:—"These connectors are two little tubes soldered together, and you run the wires in and then twist them." For iron wires the tubes are made of iron, and for copper wires of copper, so as to avoid galvanic action. The tests made by the Long-Distance Telephone Company are said to have proved that this joint takes the same breaking strain as any other portion of the line, while the Britannia joint breaks at a tension 15 or 20 per cent. lower. We confess to finding some difficulty in swallowing this story, though it comes on excellent authority. We should like to know whether any of our readers are in a position to endorse the statement.

THE "TRANSACTIONS" OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The American Institute of Electrical Engineers has lately determined that the *Transactions* of each monthly meeting shall be printed and published separately as soon as possible after the meeting has been held, instead of being withheld, as hitherto, for an annual volume. This change will, we are sure, tend to increase the usefulness and importance of the American Institute. The first number issued under the new *régime* (forming the commencement of the fifth annual volume) has just reached our hands. It contains a valuable paper, by Mr. A. Reckenzaun, "On Electric Street Cars; with Special Reference to Method of Gearing." Mr. Reckenzaun dealt in turn with each of the following kinds of gear:—Steel spiral cords, chain gearing, conical discs and chains, belting, spur gearing, friction gear, and the worm and wheel gear. Mr. Reckenzaun has apparently seen no reason to modify his preference for the latter form of gear, of which he has long been the champion. If possible we shall take an early opportunity to reprint this paper.

AGGLOMERATE LECLANCHÉS.—MM. Bender and Francken give the following recipe for making agglomerate Leclanché cells:—

Manganese peroxide	40 per cent.
Graphite	44 „ „
Gas tar	9 „ „
Sulphur	0·6 „ „
Water	6·4 „ „

These substances, says the *Révue Scientifique*, are reduced to a

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fine powder—gas tar and water apparently included—they are then carefully mixed, placed in a mould and strongly compressed. The mixture is then gradually raised to a temperature of 350deg. C., which not only evaporates the water but also drives off the volatile elements of the gas tar. This result is aided by the presence of the sulphur; a portion of the sulphur combines with the gases derived from the tar and disappears, while the remainder is said to combine with the solid ingredients, producing an unassailable compound, by a transformation analogous to that of the vulcanisation of india rubber.

THE ALLEGED EXTRAORDINARY OUTPUT OF MOTOR-GENERATORS.—If any of our readers are not perfectly clear as to the definition of a "motor-generator," we beg to refer them to a further note and also to an article which will be found on another page. Meanwhile we wish to call attention to the following statement which is given by the *Electrical Review* of New York, apparently on the authority of the inventor. Assuming the statement, to be correct, it appears that "a 100-light induction coil transformer [of ring shape] for alternating currents, costing $200, when placed in a field costing $100, and used as a motor-generator, will run 1,000 lights, *and the output is limited only by Foucault currents.*" We all know that a rotating coil may be used at a higher current density than if stationary, but that the difference is in the ratio of 10 to 1 will, we imagine, be a revelation to most of our readers. It is still more startling to learn that the output is limited only by Foucault currents. The only reasonable suggestion that we can offer is that the writer confines himself to the consideration of the section of the iron core, and assumes that the diameter of the wire is capable of indefinite increase. We shall await further information with considerable interest.

CONTINUOUS CURRENT TRANSFORMERS OR MOTOR GENERATORS.—The opinion has been hazarded that the distribution of electrical energy will in the long future be carried by means of continuous current transformers, or (as they are now called in America) motor-generators—always provided that our ideas are not revolutionised meanwhile by some overwhelmingly novel departure. However this may be, it is highly satisfactory to know that this method of distribution is at length to be put to the test. When it is added that the scheme is promoted in New York by T. A. Edison, it is a sufficient guarantee that the system will obtain a trial under most favourable conditions for the development of its latent capabilities. A full and illustrated description of the several patents under which Edison is working will be found in another column. We reserve a critical discussion of this system for another issue. Moreover, by one of those remarkable coincidences which seem to be the peculiar characteristic of electrical industry, it so happens that we have just received MSS. and drawings, giving a complete account of a system running on very similar lines which has been worked out on this side of the Atlantic. Meanwhile, what are Messrs. Paris and Scott doing?

THE PROJECTED FRENCH CABLE TO THE ANTILLES.—The *Bulletin des Société de l'Electricité* gives currency to the statement that M. d'Ockza has succeeded in forming a syndicate with a capital of 20 million francs, in order to carry out the long-talked-of scheme for laying a cable to the Antilles. It will be recollected that in the spring of the present year the Chamber of Deputies definitely refused to grant a subvention for this undertaking. M. d'Ockza and his friends wish it, however, to be understood that they are sufficiently enthusiastic to face the financial risks involved in the scheme even without the aid of a Government subvention. It is stated, moreover, that the core of the cable is to be manufactured by the Société Générale des Téléphons, at Bezons, but that it is to be armoured in this country at Henley's Telegraph Works. It need hardly be said that this will prove not only a very expensive but also a very risky method of getting the cable made. The *Bulletin* hints that the scheme is probably intended to remain on paper, and that it has been floated in part for the encouragement of the shareholders of the Banque-Franco-Egyptienne, who are largely concerned with the affairs of the Société Générale des Téléphons. We give these rumours for as much as they may be worth.

THE U. S. GOVERNMENT VERSUS THE AMERICAN BELL TELEPHONE COMPANY.—The celebrated action in which the United States Government applied to have the Bell Telephone patents cancelled came before the Court at Boston on the 26th September, and resulted once more in victory for the Bell interest. On behalf of the Government it was prayed that the Court would decree that the said patents are and have been since the date of sealing and delivery null and void; that they were wrongfully procured to be issued by means of fraud, false suggestion, concealment and wrong on the part of Mr. Bell, and that the American Bell Telephone Company may be perpetually enjoined from making use of any right or claim under said letters patent, or from alleging the same in any court within the United States as evidence of any grant or right conferred on Mr. Bell. The Court arrived at the conclusion, first, that no provision existed in the Statutory law enabling it to decree the cancelling of a patent, and it was further of opinion that the Government had exceeded its powers in making such application. It is reported, however, that the case will be carried to the Supreme Courts. Should the Supreme Court sustain the present decision, it would not be surprising if the Telephone Company brought an action against the Government to recover damages. One peculiarity of American lawsuits is that one never knows where to find them. This case, for instance, was first heard of in the courts at Memphis; it next turned up at Colombus, Ohio, and is now decided at Boston.

THE HEATING OF POINTS BY ELECTRIC DISCHARGE.—The French Academy has of late had very little electrical matter under discussion; the last number of the *Comptes Rendus* contains, however, a couple of electrical papers. One of these is of a mathematical character, dealing with the graduation of the quadrant electrometer, by MM. P. Ledeboer and G. Maneuvrier. The second is a note of M. Semmola on the heating of points by the electric discharge. It seems doubtful whether very much importance can be attached to the question, but however this may be there can be no doubt as to the ingenuity of the method by which it was investigated. M. Semmola took a pointed metallic stem, of which one half consisted of antimony and the other of bismuth, the two halves being joined longitudinally. The point being attached to the conductor of an electro-static machine, the two metals were also connected with a low resistance galvanometer. When the machine is placed in action a thermo-electric E.M.F. is generated, which is, of course, proportional to the rise in temperature of the point compared with the base of the stem. The most interesting result thus obtained was a proof of the fact that the discharge of negative electricity produces greater heat than a positive discharge. An actual spark discharge, even when nearly continuous, produces much less heat than the glow discharge. The "electric wind" which issues from a point is itself above the temperature of the air. The author suggests that a compound point of this character might sometimes be

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used to advantage in exploring the electrical condition of the atmosphere.

THE PHYSICS OF THE SUN.—The October number of the *Phil. Mag.* contains three separate articles devoted to the physics of the sun. If any apology be thought necessary for calling attention in these columns to a subject of such profound interest, it may be sufficient to recall the fact that but for the agency of electricity in obtaining comparison spectra it would be impossible to pursue the inquiry as to the presence of the terrestial elements in the solar sphere. The first of these papers is a record of the results of a new research undertaken at Harvard University by Prof. J. Trowbridge and Mr. C. C. Hutchins with a view to the verification of Prof. Draper's discovery (in 1877) of the presence of oxygen in the sun. This discovery has never until now been seriously called in question. Prof. Trowbridge was, however, enabled to bring to bear far more powerful appliances, and in the result he is led to the conclusion that there is no evidence of the existence of oxygen in the sun. The comparison spectra was obtained by means of a spark discharge in air, furnished by the secondary coils of three large induction coils, in which the primaries were traversed by an alternating current. Great difficulties were experienced from the heat developed. The electrodes consisted of two stout aluminium rods. The second paper is devoted to the question of the existence of carbon in the sun, and to this an affirmative answer is returned. These experiments, which were also carried out at Harvard College, were made by means of the ordinary arc between electric light carbons. The authors were led to conclude that at the point of the sun's atmosphere, where carbon is volatilised, the temperature of the sun approximates to that of the voltaic arc. The third paper, by Prof. A. Grunwald, is on the "Dissociation of Hydrogen and Oxygen in the Sun's Atmosphere."

THE TELEPHONE SIREN.—Dr. Karsten writing in the *Elektrotechnische Zeitschrift* describes an instrument under the name of the telephone siren which consists of a disc on which a number of bar magnets are arranged radially with their similar poles adjacent. By means of a clockwork driven by weights this disc is made to revolve in front of a fixed iron core upon which a coil of wire is wound. A telephone receiver is placed in connection with this coil, and on rotating the disc the induced currents set up a clear and distinct note in the receiver. The pitch of the note may obviously be changed either by altering the speed of rotation or by varying the number or the arrangement of the magnets. If the inner poles are arranged N, N, N, &c., a certain note is produced at a certain speed; with the arrangement N, S, N, S, &c., the note is an octave lower; with the arrangement N, N, S, N, N, S, three tones are simultaneously heard. The highest of these is given as being the same as in the first arrangement, the next is an octave deeper, and the lowest is a fourth to this octave. When a sufficiently powerful motor is used to revolve the disc, tones of equal loudness throughout can be produced, and when compared with those emitted by other instruments the well-known beats are clearly audible. The telephone siren can therefore be used to determine the vibration-frequency of any note, as well as to prove the principle of interference caused by vibrations whose wave-lengths are opposite in phase. The instrument is also applicable to the telephonic determination of electrical resistances in which equality of resistances in a Wheatstone bridge is detected by an absence of sound in the telephone. This mode of testing is often rendered uncertain by extraneous disturbing sounds, but the clearness of tone of the telephone siren can always be distinguished from superposed sounds from other sources.

THE FIRE OFFICE RULES.—We are extremely glad to see that the vexed question of fire office rules which threatened to work such confusion in the electric lighting industry has been practically settled—and that in the common sense manner which might have been expected when the subject was taken in hand by business men. The efficacy of the Phœnix rules themselves has never been brought into question. The only plea raised on the side of the malcontents was that one or two offices did not care for the title page of the pamphlet. Two or three weeks ago a leading office placed themselves in communication with the Phœnix, with the view of settling once for all any objection that might ever arise on this score, and its suggestions were accepted. They were simply this—that the Phœnix rules be issued in two separate covers, one with the well-known title, the other with the title altered to "The Fire Office Rules"—this last form to be used by any persons who were sensitive as to the former title. We have received a copy of the latter issue together with the 10th edition (second issue) of the Phœnix rules, which, as already stated, are identical save for the covers. With regard to any particular rule itself, it is well known that Mr. Heaphy, on behalf of the interests he represents, is perfectly willing to give every attention to such suggested modifications as may be made at any time, provided that such alteration does not injuriously affect the insurance interest. The Phœnix Fire Office has never shown the slightest desire to impose any harsh or unjust restrictions, but, on the contrary, to give the freest possible scope to electric light industry, in the fullest manner compatible with safety. In this matter we can only repeat what we have already said, that the electrical interests are in England placed in a far more favourable situation than in any other country. It may now be hoped that this agitation, which cannot be otherwise than injurious, may be allowed to die a natural death.

EFFECTS OF LIGHTNING ON RAILWAY SIGNALS.—The *American Railroad Gazette* writes on the above subject as follows:—"The effect of lightning on electrical apparatus of all sorts is a subject on which accurate data seem rather scarce, and its effect on railroad signals especially is a point on which more light is needed. A cardinal principle in signals which are in any degree automatic is that they shall show danger in the event of any derangement, and numberless ingenious devices have been invented to provide against the possibility of a signal standing at safety when it has not been intelligently put in that position; but lightning is such a lawless element, and may influence electrical apparatus in so many different ways that the counteracting of the harm it may do is not an easy task. It may make a ground connection, and thus allow a circuit to appear all right when it is not, being closed at one end and open (without battery) at the other. It may melt fixtures so as to permanently hold a signal in the position it is in at the moment; and again it may charge a wire with a current that will actuate the electromagnets and work the signals when the signal man has taken no action whatever. While the chances of a signal being held any length of time in the safety position from the effects of lightning alone are very small, and while it is probable that nearly or quite all danger in this respect can be guarded against by cautionary instructions to the attendants, it is nevertheless well to make note of all peculiarities noticed, that experience may be compared. In a recent thunderstorm at Palmer, Mass., the electric locks on the interlocking machine at the crossing of the Boston and Albany and New Londo

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Northern were alternately locked and unlocked several times by atmospheric electricity in the rails at and near the crossing. The storm also showed one of the disadvantages of underground wires. A lightning shock generally runs along a wire until it encounters more than ordinary resistance and then melts the conductor. An underground wire is more likely to have unequally corroded sections than an aerial one, and so furnishes first class opportunities for the lightning to fuse and part it, where, in the case of a wire hung in the air, the resistance and damage would more likely occur in the office connections or apparatus."

SHOCKS FROM DYNAMO MACHINES.—We have recently published from American sources several contributions to our knowledge of this important though painful subject. The following is an extract from a letter addressed by Mr. C. Smith, of Pittsburg, to our esteemed contemporary the *Western Electrician* of Chicago. Mr. Smith is criticising a paper read before the Chicago Electric Club by Mr. C. C. Haskins. He says :—"As Mr. Haskins wishes to know 'full particulars' as to the shocks that I have received, and of which I spoke at Boston, I will give them to him, and he can repeat the experiments whenever he likes and compare results. Let him take a 30-light Brush machine, running with a full load of lamps, take hold of the bare wire in one hand and a brass coupling in the other, and pull them apart. (I did this, of course, not knowing that the current was on the wire.) Result: A couple of burns on the hands, a knock down off a step ladder, and blue spots and general stiffness and soreness in both arms and across the chest for a week afterwards. Secondly, let him stand with wet feet on the wire running from the negative terminal of a Thomson-Houston 20-light machine, and hold on to the positive terminal while somebody else—with the idea of releasing him—opens the line. Result: Burnt hands and blistered feet. Thirdly, let him come into one of our alternate current stations where the bars of the switch-board are of bare copper about one foot apart, with a difference of potential between them of 1,000 volts, and let him, while coupling in a new circuit, place one hand on each bar. Result: Two little burns, about the size of pin heads, on each hand. After these experiments he will be in a position to criticise. Mr. Haskins showed in one of his experiments that he got a spark and a shock from the extra current from a magnet with six Leclanché cells. If he will call at our station in Pittsburg, I should be happy to show him the breaking of an alternate current of 65 amperes at 1,000 volts (the full current of one of our 1,300-light dynamos), with no more spark than would be seen in the breaking of a direct current of two amperes at 100 volts, and in about three weeks I expect to be able to show him 130 amperes at 1,000 volts (or 2,500 lights) broken with no greater spark. Mr. Haskins does not seem to have at all understood the purport of my remarks, which was not that the 1,000-volt alternate current is harmless, but that the 1,000-volt alternate current is very much less dangerous than the 1,000-volt direct current, and I would call his attention to the fact that his spark and shock from the six cells of battery and magnet is a direct current, and not an alternate current, and may easily be of many hundred volts."

PROF. EWING ON THE PRESENT POSITION AND PROSPECTS OF THE ELECTRIC LIGHTING INDUSTRY.—On Monday last Prof. Ewing gave the first of a course of ten popular lectures on electric lighting in the Engineering Class Room of University College, Dundee, the subject of the introductory lecture being "The Present Position and Prospects of the Electric Lighting Industry." After some preliminary remarks the lecturer went on to speak of the progress in electric lighting during the last five years, under the several heads of production of electricity, storage, distribution, and lamps. The apparatus was now vastly more efficient and very much cheaper. Dr. Fleming had lately shown that the first cost of a large dynamo was then about £2 per lamp, now it was only 7s. Lamps were now more durable. Storage batteries are trustworthy and permanent. By transformers it had become possible to convey electric energy in the form of a current of small quantity at great pressure, thereby requiring only small conductors, and then convert that into currents of large quantity and low pressure suitable for ordinary domestic use. By this means the problem of economically distributing electricity for incandescent lighting from a central station was in a fair way to be solved, and in the last year Mr. Westinghouse had put up 27 such stations. The electric meter of Prof. Forbes, made public only last month, would serve to tell how much electricity each householder was consuming, just as a gas meter did for gas. Apart from the question of general distribution from central stations, the electric light was now an assured success as the illuminant of large open spaces, of ships, of exhibitions, of theatres, of the country mansions of the rich, and of mills and factories. The question that determined the use of the electric light was almost wholly a question of cost. Was it or was it not cheaper than gas? To that question it was now possible to give a definite answer. Supposing, as was often the case in Dundee mills, the power required could be taken from the mill engine, then wherever night work was to be done electric lighting by incandescent lamp was unquestionably cheaper than gas. If there was only day work—that is, if light was required only for a few hours in the early morning and the late afternoon of the winter months—then gas and electricity ran almost neck and neck as regards cost; but if light was wanted for anything like a thousand hours in the year then electricity was distinctly cheaper, even allowing in the most liberal way for interest and depreciation on the permanent plant, as well as for the cost of lamp renewals, coal, oil, &c. More than two years ago he pointed this out in a lecture in Dundee as the result of a calculation, and shortly after he had the opportunity of making practical proof in mills in the Dundee district where he had been consulted professionally regarding the electric light. In one of these factories the calender was lighted by electricity, and was used occasionally for night work. After two years' use the manager had given him figures for the actual cost. For 1,200 hours' work during one year the whole cost of lighting by electricity, including interest and depreciation, was under £50. The same area had formerly been lighted by gas, and the gas bill for the same number of hours' work had been £82. If the plant had been of the most modern kind the difference would have been still greater in favour of electricity. In another case, in the underground warehouse of a Dundee mill, where they had formerly made shift to work with the dimmest light for fear of fire, the electric light had been introduced under his supervision, and the results had been very interesting. He recommended that as a brilliant light was not wanted the lamps should be worked, for the sake of economy, at a low degree of incandescence. This had been done, and some of the lamps, burning every working day for ten hours, had lasted for more than 7,000 hours. Their average life had been 5,500 hours. In conclusion, the lecturer said there were many signs that the electric light industry, after a long time of great depression—during which, however, the engineers had not been idle—was about to enter on a period of rapid growth.

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THE RISE AND PROGRESS OF TELEPHONY IN THE UNITED KINGDOM.

(Continued from page 413.)

Having related in the last chapter how it came to pass that the plea of premature disclosure (at Glasgow and in the columns of the press) of the principle of the Bell telephone resulted in a judicial decision in favour of the holders of the patent, we arrive now at the second chief line of the defence adopted by Messrs. Harrison, Cox-Walker and Co. In this it was sought to be shown that the invention of the telephone had been anticipated by Philipp Reis. It will better accord with the method of our brief historical survey if we deem it unnecessary, in the first instance, to confine our account to the evidence actually produced at the trial. By dint of availing ourselves of the subsequent labours of Prof. Silvanus Thompson, we shall be enabled to present a clearer account of what Reis actually accomplished, and thus to do justice to the memory of a remarkable and highly gifted man, whose scientific fame should in no degree be affected by the fact that his researches did not lead to immediate practical results. The limits of the case as presented in the English courts, and the points upon which the judicial decision was subsequently based will be indicated in due course.

In the year 1860 Philipp Reis, at that time a schoolmaster at Friedrichsdorf, commenced his researches on the transmission of speech by electricity. In a letter* to Professor W. F. Barrett, Dr. Messel, a former pupil of Reis, thus describes the primitive apparatus which the inventor first con-

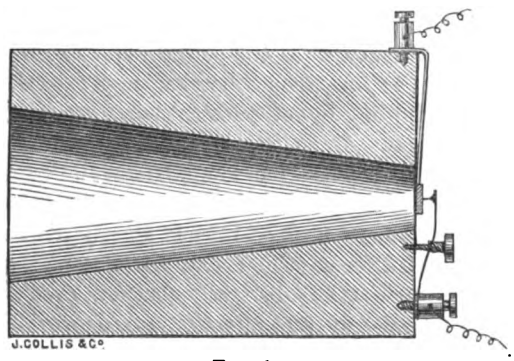

FIG. 1.

structed. "The transmitting instrument was a bung of a beer-barrel hollowed out, and a cone formed in this way was closed with the skin of a German sausage, which did service as a membrane. To this was fixed with a drop of sealing-wax a little strip of platinum corresponding to the hammer of the ear, and which closed or opened the electric circuits precisely as in the instruments of a later date." In Prof. Silvanus Thompson's work no less than ten different and successive types of the Reis transmitter are illustrated and described, but as to their essential parts they are every one practically identical with the original instrument described by Dr. Messel. By the kind permission of the author we are enabled to reproduce some of the illustrations from the work in question. Fig. 1 shows the form of Reis transmitter which has been called the "hollow cube." The following is the original description† by Prof. Böttger, which appeared in the *Polytechnische Notezblatt* in the spring of 1863:—"A little light box—a sort of hollow cube of wood—has a large opening at its front side and a small one at the back of the opposite side. The latter is closed with a very fine membrane which is strained stiff. A narrow springy strip of platinum foil, fixed at its outer part to the wood, touches the membrane at its middle; a second platinum strip is fastened by one of its ends to the wood at another spot, and bears at its other end a fine horizontal spike, which touches the other horizontal spike where it lies on the membrane."

A great controversy has raged around the question as to the precise mode of action of these transmitters of Reis, whether by actual interruption of the circuit or by variation of contact resistance; it has even been denied that they were capable of acting at all in the sense of transmitting articulate speech. On the latter point, however, the testimony adduced by Prof. Thompson seems to us conclusive, but we are equally inclined to believe that the action of the Reis transmitter was "microphonic" in character, being due to the variation of resistance of a loose contact. We base this conclusion upon the ground that no satisfactory evidence has yet been adduced that an actual make-and-break action is capable of transmitting articulate speech—a feat which the Reis instrument accomplished. That a platinum contact is immensely inferior to a carbon contact, and that no results sufficiently reliable for commercial use have been obtained with the former class of transmitter, needs not to be said.

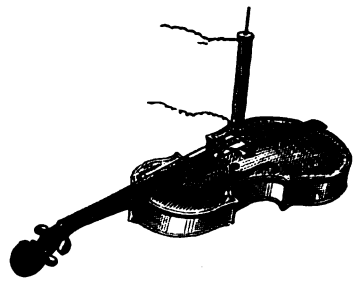

FIG. 2.

So far we have dealt only with the transmitting instrument, but in the Harrison, Cox-Walker trial it was the receiver which was brought upon the scene of action. Reis's original receiver is illustrated in Fig. 2. A careful examination of the figure will probably disclose the fact that in this instrument there were certain superfluous accessories. In fact, it consisted of a violin (lent to Reis by a certain Herr Peter, music-teacher of Friedrichsdorf), upon the bridge of which was stuck upright a knitting-needle surrounded by a coil of silk-covered copper wire. In a paper "On Telephony by the Galvanic Current,"* read before the Physical Society of Frankfort-on-the-Maine, on October 26th, 1861), Reis explains that this wire was magnetised in varying degrees by the successive currents, and when thus rapidly magnetised and demagnetised it emitted tones depending on the frequency and strength of the currents which flowed through it. The violin acted, of course, as a sounding-board to reinforce the sound. This instrument is now preserved in the Garnier Institute at Friedrichsdorf.

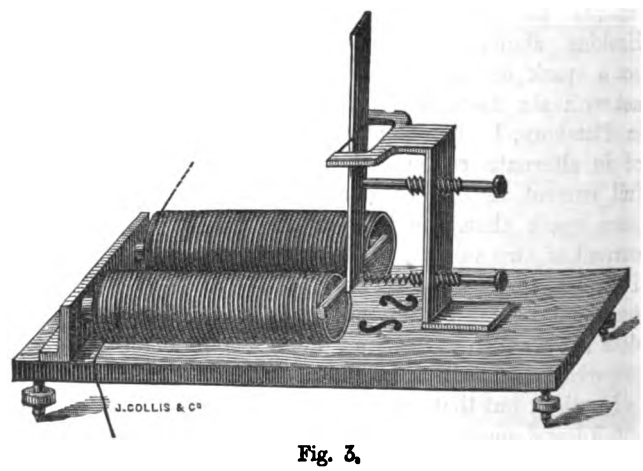

Fig. 3.

The success of the violin experiment naturally led Reis to the construction of a receiver in which the knitting needle was mounted in a horizontal position on a special sounding board. Of this instrument several types were made differing in various points of detail. It is a singular fact that while every one of the Reis transmitters is provided with a more or less elaborate mouthpiece, the receivers were never provided with any similar appendage, although modern practice has proved that this feature is more important in the latter case than in the former.

* See "Philipp Reis, Inventor of the Telephone," by Silvanus P. Thompson, page 15. (E. and F. Spon.) † *Ibid*, p. 21.

* See "Philipp Reis, Inventor of the Telephone," pp. 11—29.

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The most interesting, and for the purpose of the Harrison, Cox-Walker defence the most important, of the Reis receivers took the shape of Fig. 3. In this instrument we have a double electro-magnet, about 6in. in length, laid horizontally on a wooden sounding board. In front of the poles is an iron rod of elliptical section. In the centre of this armature a wooden lath is attached at right angles; a tension spring and a couple a adjusting screws complete the essential portions of the apparatus.

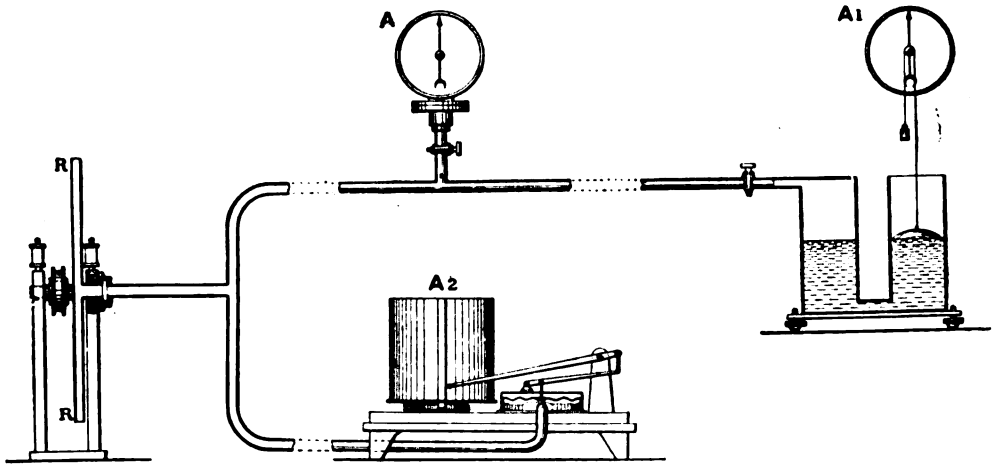
(To be continued.)

THE AMERICAN NATIONAL TELEPHONE EXCHANGE ASSOCIATION.

The ninth annual meeting of this Association was held at Pittsburgh on September 26th and 27th. The papers read were of the usual practical and businesslike character, and a most satisfactory rate of progress was reported in almost every direction which arose for discussion. An interesting paper of a retrospective character on "Ten Years of Progress in Practical Telephony" was read by Mr. Lockwood. The subject is a very tempting one, and in the hands of Mr. Lockwood could not fail to become both entertaining and instructive, and this notwithstanding the fact that the author is not altogether free from the prevailing faults of American technical writers. Had the paper been half as long it would have been at least twice as readable and equally instructive. The progress of the last few years in the art of telephony has in America been as much moral as material. In the words of another member of the association the time has arrived when practical men have completely reversed the old idea that "anything is good enough for a telephone line;" now he would say, "nothing is good enough, at any rate the best is not too good, for it has been most emphatically proved that in the long run the best is the cheapest." This excellent frame of mind has been largely due to the extension of long-distance telephony, and the recognition of the fact that however perfect the intermediate line may be, yet if the local connections are bad the results can never be satisfactory. On this point Mr. Lockwood was very explicit. "It cannot be emphasised too frequently that the short exchange lines have got to be well built; they have got to be built in just the best way we know how; the line wire must be good; the insulators must be good; the joints must be made in the best way." A paper by Mr. E. J. Hall, jun., entitled "Notes on Long-Distance Telephone Work," described the New York-Philadelphia line, which was built to the following specification:—Poles to be not less than 7in. in diameter at the top and from 45ft. upward in length; to be set 6ft. in the ground on straight lines and 7ft. on corners or sharp curves. The poles were prepared for seven ten-pin arms, and three arms were at once put on, carrying 24 copper wires. In addition to the copper wires, one No. 8 iron wire was strung on a top pin to strengthen the line (especially during construction). The utmost pains were taken in guying and bracing, and the good results of this care in building have been fully demonstrated by the nominal expense of maintaining the line since it was finished. The total length of the line is about 100 miles, and on the average 40 poles to the mile were employed. On the completion of the line, notwithstanding the fact that the circuit was a metallic one, it was found that a good deal of "cross-talk" (as the Americans expressively term it) still had to be contended with. "We determined," said Mr. Hall, "not to offer an imperfect service to the public, and months of hard work resulted in perfecting a simple and practical method of absolutely removing all trouble from this cause." Unfortunately the author did not proceed to specify the nature of this sovereign cure. The report of the secretary on Exchange Statistics, and a paper by Mr. W. D. Sargent on "Underground Wires," concluded the business of the meeting. We hope to return to these matters next week. Meanwhile it is gratifying to notice that in America, as well as in England, the "moral," or as we should prefer to call it, the commercial, aspect of telephone engineering is beginning to be fully appreciated.

RUNG'S PNEUMATIC SPEED INDICATOR.

The Thomson-Houston dynamos in the electric lighting shed at the American Exhibition have recently been furnished with a set of pneumatic speed indicators supplied by Messrs. Capito and Hardt. This indicator is the invention of Captain G. Rung, of the Danish Artillery, and has already been in use for about a year and a-half in the Danish Navy, where it seems to have given great satisfaction. The principal merit of this invention lies in its extreme simplicity, and consequent cheapness and non-liability to get out of order. The apparatus consists, first, of a rotating tube acting as a centrifugal exhauster; this is connected with a pipe leading to an indicator, by which the air pressure within the pipe is made to exhibit the number of revolutions per minute of the exhauster. Several different forms of indicator are constructed by Messrs. Capito and Hardt, and in the adjoining illustration three independent methods are shown. In this figure R R is the rotary tube, which is driven from the shaft of the dynamo or other machine. A is an indicator, constructed precisely on the principle of the aneroid barometer, and of which, therefore, no further description is necessary. The scale is calibrated, so as to be read directly in revolutions per minute. Another form is indicated at A_1 in which a U-tube containing water is employed, one branch being connected with the rotating exhauster and the other remaining open to the atmosphere. The difference of pressure in the two limbs, which is proportional to the speed, is indicated, as in the ordinary mercurial barometer, by means of a float attached to a cord passing over a pulley carrying an index hand, and which is counterbalanced by a weight. This is a very sensitive and also a very accurate arrangement. Evaporation is compensated for by means of a small plunger, not shown in the figure, by adjusting the position of which the needle may be set to zero at any time. A_2 represents a recording arrangement, in which the point of a bent lever traces a line upon a sheet of paper wrapped on a cylinder, which is rotated by clockwork. The position of the lever is determined by the degree of exhaustion in an aneroid chamber.



Rung's Pneumatic Speed Indicator.

In addition to the advantages already named, there are two important features which may be said to be almost peculiar to this system. It permits of an accurate indication of the speed of any class of machinery at any distance from the machine itself. And a single indicator may be applied successively to any number of rotators; it is usually sufficient to have only one indicator connected with a common reservoir, to which the pipes from the rotators can enter through stop-cocks. The latter feature is of course an admirable one from the economical standpoint. The arrangement just described, together with the aneroid type of indicator, may be seen at work at the American Exhibition, and those engineers who have not already done so will find it useful to inspect the apparatus before the Exhibition closes at the end of the present month.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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NOTICE.

We beg to notify that all correspondence and contributions intended for this Journal should be in future addressed to THE ELECTRICIAN, 1, Salisbury-court, Fleet-street, E.C., instead of to Mr. C. H. W. Biggs, whose connection with it has ceased. Business communications should be addressed to "The Publisher," and cheques and money orders made payable to "The Proprietors."

MANUAL TRAINING.

One of the minor subjects on which an Association of Electrical Engineers, referred to in another column, would claim to have a voice is the manual training of our artisan classes. Various circumstances have combined to bring this vexed question to the front during the present year, and an abortive attempt was made in Parliament to establish a system of technical instruction in our Board Schools under the guidance of South Kensington. We disapproved of this scheme at the time, and are glad that for once in a way Parliamentary obstruction did a useful turn, without meaning it, by compelling Sir W. HART-DYKE to withdraw his Bill. Before next session the subject will, to all appearance, be fully discussed in the public press, and possibly a solution of the whole difficulty may be arrived at by a practical experiment which, if successful, will be worth far more than any Act of Parliament. The Chairman of the London School Board, by far the largest educational machinery in the whole country, has announced that the manual training of boys in the elementary use of tools, the handling of them, and broadly in the exercise of those faculties by which the lads will have to gain a livelihood, has been started in certain of the London schools. The auditor of the Educational Department has, of course, vetoed the expenditure, although it amounted to only a few thousand pounds; but we may safely infer from the Chairman's observations, and from the general approval with which his scheme has been received, that it will not be abandoned for want of funds. It is not pretended that the manual training now being given to boys in these Board Schools—and to which they are certainly as much entitled as are the girls to needlework and cookery—will provide the technical instruction for which there is so great an outcry; but it is a step in that direction, and if followed up will help us to see exactly what it is we need.

What is really needed and what is demanded may be two quite different things, not attainable in the same way, and possibly not both worth attaining. We have before now confessed that we do not quite understand what is meant by technical instruction in relation to the great bulk of the classes who attend elementary schools. A scientific education is out of the question unless the period of tuition be prolonged beyond all reasonable limit; and it is far from certain—we should say the certainty is all the other way—that a scientific education would be of the least use to the Board scholar when he had got it. Yet it is evident that a scientific education is what is meant by those who talk loudest about technical education. The two things are not necessarily the same. Scientific education in the South Kensington interpretation of the term is certainly not technical, and technical education, though in a sense scientific, is by no means what the scientists would prescribe. We very much fear that scientific professors are responsible for much of the delusion prevailing on this point, and we have heard it roundly asserted that the said professors are mainly anxious to enlarge the area of their professorial functions. We want technical education for our workmen, say the manufacturers. We will give it you with pleasure—and for a consideration—reply the scientists; but when we come to look at what they offer it is not at all the thing the manufacturers or their workpeople want. Fairness, however, compels us to add that nobody else has responded to the demand; and it is only natural that scientific teachers should offer the wares they have to sell in the absence of a better commodity. In our opinion the spontaneous experiment now being tried in the London Board Schools, and which will almost certainly be imitated elsewhere, is far more likely to provide the genuine article than anything that has been so far offered in the guise of "technical instruction."

The instruction in certain branches of science has a useful sphere of its own; it encourages learning, spreads scientific knowledge, and, if followed up, results in the rearing of men qualified to superintend and direct by scientific methods the work of the industrial classes. But this is not the technical instruction which is closely related to handicraft, to manual dexterity, to knowledge of a particular calling, and to the complete mastery of its manipulation. If the nation needs the former, by all means let the nation have it; but in that case it must be given to the class that requires it and can use it, not to the workman who needs it not, and who is, we will not say better without it, but better employed in learning what he really needs. On the other hand, if our artisans are deficient in the technical knowledge of their callings, that, too, ought to be given to them. But the technicalities of a trade, unlike the science which embraces all trades, can only be learnt in the workshop; and the best encouragement we can give to that sort of knowledge is to get the pupil into the workshop as soon as possible, and make it his pride and privilege to become an adept. The old system of apprenticeship is perhaps not dead past recall. The powerful trade Guilds might do much to revive it, or substitute something equally useful in its place. Board Schools might

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do a little by paying the premiums of apprenticeship as a reward of merit. In this way the dignity of labour would be impressed on the youthful mind; and one of the most hopeful signs about this manual training for boys in the London Board Schools is that it will teach them a lesson much needed in these days, namely, that skilled labour is a more excellent thing than book learning. As the *Saturday Review* remarks, there were no good workmen to be found in Laputa, though it abounded in *savants*.

A most remarkable contribution to this discussion comes to us from Germany through our contemporary the *Engineer*. The extract which we printed in our last week's "Notes" under the heading "Technical Instruction," is as startling as it is instructive. We have been sending Royal Commissioners all over the civilised world to ascertain why other nations are so much cleverer than ours. They duly reported that the reasons were to be found in the superiority of the technical training which prevailed abroad, notably in Germany. But apparently this is not the opinion which Germans themselves entertain. If they are superior they do not seem to be aware of it; and what is still more surprising they point to England as a pattern for Germany to imitate. Several German professors have been recently holding forth at various universities on the subject of higher education, the general verdict being that in Germany it is too theoretical, and the scholars too deficient in practical sense. Comparisons are also made between the systems of Germany and England, not to the disparagement of the latter; and a leading industrial paper points out that what is needed for Germany is the scheme of education, technical and practical, which has done such great things for England. We suspect that what is here said of the higher education applies equally to the lower and middle-class. "Schooling" is there pushed to its extremest limits; but manual, technical, and practical education is as much neglected there as here. In Germany, however, they seem to understand precisely what they want; in England we have hardly yet cleared our ideas on this preliminary stage of the problem.

THE PROPOSED ASSOCIATION OF ELECTRICAL ENGINEERS.

Our readers will be glad to learn that the adhesions we continue to receive in support of the proposal for the formation of an Association of Electrical Engineers are so numerous and so cordial that to ensure the success of the scheme little remains to be done except for representative men in due time to come together and set it going. We hope shortly to make a more definite announcement as to this preliminary step. Meantime we shall be glad to hear from correspondents interested in the several branches of electrical industry concerned, either for our information or for publication in this journal. We have indicated already some of the more prominent subjects which a Congress of Associated Electrical Engineers would probably have to take into consideration at the very outset. In due time we propose to discuss these subjects separately, one by one, in our leading columns, with the fullest regard to the business interests of the Association. Our views in a general way have been made known on most of the points in question when circumstances have forced them into public notice; but it is obvious that, taking these matters in hand, so to speak, at a moment's notice, a trade organ is always at a disadvantage unless it is in complete possession of the views of its clients. And before resuming the consideration of such questions as, for example, Electric Locomotion, the Electric Lighting Act, and the attitude of Parochial Authorities towards Telephone Extensions and Electrical Engineering operations generally, we advise the heads of firms to put themselves in communication with us, assuring them that their individual suggestions, as well as their business interests, will receive the carefullest consideration at our hands.

CORRESPONDENCE.

DISTRIBUTION BY TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While the subject of the invention of the system of distribution by transformer is under discussion, and there appearing to be a good many claimants for the honours due to those who have really made substantial advances in the art, I may be allowed to give here a few of the leading dates of what appear to me to be the most important advances made:—

1835. Faraday invented the induction coil open and closed magnetic circuit.
1856. Cromwell Fleetwood Varley perfected the closed magnetic circuit transformer, making the iron enclose the conductors and thoroughly laminating the iron, Patent No. 3059.
1857. C. W. Harrison proposed to use induction coils. In a patent granted to him; he proposes to use a primary circuit to supply the coils, and to work lamps from the secondary circuit.
1877. M. P. Jablochkoff patented the use of induction coils in a primary circuit containing the coils in series order, and working lamps from the secondary circuit.
1883. Mr. Rankin Kennedy, of Glasgow, in the *Electrical Review*, of London, pointed out the cause of the failures with coils in series order, and stated that if placed in parallel order they become self-regulating.
1885. Messrs. Zipernowski and Déri patented the use of coils in parallel order.

These dates have been mentioned by Kennedy in his pamphlet, and others, as the leading ones, and, if correct, would seem to support his view that no "master patent" exists on the subject.—Yours, &c., ROBERT MITCHELL.

115, South Woodside-road, Kelvinbridge, October 6, 1887.

PROPOSED ASSOCIATION OF ELECTRIAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am not sure if I am the Mr. Walker referred to in your note last week, but I may say that I consider the idea a very good one, and shall be prepared to support it, as far as lies in my power. If I understand the matter aright, what you propose to establish is a purely commercial association, to deal with commercial questions. We have similar associations here and at Newcastle in connection with the coal trade. In each of these places a society, or institute of engineers exists, which embraces engineers of all kinds, managers, under-managers, even agents of firms who supply goods to collieries and other works in the district. These institutes have brought before them papers on every subject bearing upon the working of collieries and other works. They go from high science to the most practical details of everyday work; but they do not discuss commercial questions, such as sliding scales, Mines Regulation Acts, &c., except so far as the engineering questions occasionally involved in them go. Side by side with these engineering societies are Coal Owners' Associations, which embrace owners of collieries and the representatives of the large coal-owning companies. These associations do discuss commercial questions, such as those I have mentioned, and others, and they may occasionally discuss new appliances for collieries, so far as their actual working goes.

I take it that the Association of Electrical Engineers you propose to establish would be analogous to the Coal Owners' Association. That they would deal with questions of a purely commercial nature principally, though possibly with others incidentally. Such questions, for instance, as the Electric

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Lighting Act; an Electric Tramway Act, if one should be necessary; the education of the electrical workman; wire gauges; the providing a standard for electrical engineers to compare their instruments by; the procuring, if practicable, of an Act prohibiting any one from practising as an electrical engineer, or working as an electrical artisan, unless he shall be duly qualified; the procuring of an Act regulating the erection of telephone and telegraph wires over towns; possibly obtaining licences under more favourable conditions from the Postmaster General; and doubtless many others would crop up from time to time.

It should be understood that the questions above enumerated, where they trench upon the engineering department, would only be dealt with by the association so far as the commercial aspect allowed. Thus, the association could lay down the most convenient conditions under which standard instruments should be available; they would not discuss, or at least only incidentally, the structural details of the instruments themselves and their fixings.

I think that the existence of such an association, if properly supported, would be of very great service to electrical engineers generally. It could speak to Parliament, for instance, or to trade councils, with the united voice of the trade. It would almost necessarily acquire importance in the country, as representing a powerful and increasing industry.

There is one thing, however, it appears to me, that it must not attempt to do, and that is to teach. As you have justly remarked, the making of the tool can be left to the societies already existing; its commercial use should be the province of the association.

Perhaps others interested in electrical engineering will give their views on the subject.—Yours, &c,

SYDNEY F. WALKER.

195, Severn-road, Cardiff, October 10th, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have already verbally expressed to you the great satisfaction I feel in seeing your excellent suggestion for the formation of an Association of Electrical Engineers taken up so well, and therefore do not propose to dwell on the desirability of such a scheme, which I feel sure will be acknowledged on all hands; yet a very clear idea of the nature and formation of the association is most essential. First of all, in what way will it affect kindred societies, such as the Telegraph-Engineers and the Dynamicables? It is not likely to affect either, for the former is more likely to trouble itself over commercial questions—by the way the Fire Office rules question is completely settled and the Phœnix rules have been universally adopted—and the latter is (or was) essentially a dining society. Can any one tell me whether the Dynamicables exist at all now? One has not heard of them for a long time, although only very shortly before their apparent decease "a local habitation and a name" was announced with quite a fanfare. I remember very well at one of the dinners, when the diners were discussing things more weighty than usual Mr. Joel ventured to suggest that we were only a dining society, and had therefore no right to take up important questions. He was howled down; and yet he was right, we were only a dining society, or why do not we exist to-day? The name, too, "Dynamicable" smacked too much of conviviality, and so for every other reason (if not for its deceased nature) the nature and functions of the new society are not likely to clash with those of the Dynamicables.

The name "Association" is an excellent one, for it suggests its functions at once. We have associations of every kind throughout the country the duties of which are the nursing and fostering the interests of the trades they respectively represent. They are not scientific societies—there are these in addition—they are distinctly trade or commercial societies. For instance, there are the Masters' Association, The Coal Owners' Association, Miners' Association, &c., whose functions, I take it, are similar in their trade to those of the new association in its trade.

Having, therefore, a clear idea of the nature of the association, we are at once enabled to suggest some of the questions which loudly call for discussion and united action by its members. These, however, I think might well be left to a committee, so that the sooner a committee is formed the better. One question I will mention, fearing it may be overlooked, and that is the necessity of an Electric Tramway and Railway Act. The age of heavy electrical engineering can hardly be said to have commenced until we have mastered the "traction" question and taken it up in earnest; it is therefore all important to be prepared with the general outline of a Bill that would meet with the general approval of the electrical world.

Mr. Statter is not new in bringing examples of bad work before your readers, but as yet the association can hardly assume the mantle of the pedagogue, nor can its functions be those of the Board School. Those who do not know how to couple up compound-wound dynamos in parallel had better consult the text books. It would scarcely be decorous to castigate them with the birch of the association.

I wish you, Sir, hearty success in your efforts to carry this suggestion to a practical issue.—Yours, &c.,

J. M. V. MONEY-KENT.

Connaught Mansions, Victoria-street, Oct. 12th, 1887.

EDISON'S SYSTEM OF CONTINUOUS CURRENT TRANSFORMERS.

At Llewellyn Park, one of the pleasantest of the New York suburbs, there is now under construction a central station for the supply of electric light to which a very unusual degree of interest attaches. It represents the first attempt to utilise in practice the principle of the so-called continuous current transformer (perhaps a better name is the "motor-generator"). Messrs. Paris and Scott have hitherto been the sole adherents of that system in this country, but we are not at the present moment aware that they have any plant in actual commercial operation. In the New York scheme the mains are laid out upon the three-wire system, and are to be placed underground. Two dynamos, each giving 600 volts, supply current at constant potential to the motor coils of the transformers, while the dynamo coils each give 100 volts for use upon the consumers' circuits. The generating plant is to be placed in the new laboratory which is now being built for Mr. Edison, and the whole scheme will be carried out in accordance with certain patents taken out by him. Although the existence of these patents was certainly unknown to the world at large, it appears that they date as far back as 1881, 1882, and 1883. It is further claimed for his system that a remarkable economy is effected in comparison with the cost of alternating current transformers for the same output.

Our readers will probably feel that it is desirable to obtain some further enlightenment on the subject before accepting a statement so subversive of accepted ideas.

The following description of Edison's American specifications is taken from our contemporary, the *Electrical Review* of New York:—

1. Electrical distribution system, No. 266,793; dated October 31, 1882; filed December 9, 1881.

2. Apparatus for the electrical transmission of power, No. 265,786; specification filed August 7, 1882; dated October 10, 1882. Consisting of rotating transformers in series and secondary circuits in multiple arc.

3. Apparatus for translating electric currents from high to low tension. No. 278,418; specification filed August 14, 1882; dated May 29, 1883. Induction coil apparatus, the primaries being in multiple arc, with constant potential direct-current mains, the secondary circuit being in multiple arc as usual.

4. System of electric distribution, No. 287,516; specification filed May 14, 1883; dated October 30, 1883. Rotating transformers in multiple arc, with the source of electric current.

In the interesting illustrations presented herewith (Fig. 1) is a diagram representing the disposition of induction coils connected with the rotating alternating device of which Fig. 2 is a drawing.

The induction coils H, J, K, L, M, N, O, P, are built up of a core of laminated iron on which are wound two coils of copper, one of coarse wire as shown by the heavy lines for the secondary circuit, the other of fine wire for the primary circuit. The primary coils are connected, as also are the secondary. From each connecting wire are attached brushes B^1, B^2, &c., for the primary, b^1,

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b^2, &c., for the secondary circuit. E and F are on the same shaft, and in a portion of their circumferences are inserted metallic contact pieces A, D, C, G. A and G are joined with two continuous rings on which press brushes connected with the dynamo circuit. As the shaft revolves, brushes B^7, b^7, and B^3, b^3 will touch the metal sections, A, D, C, G. The direction of the current will therefore

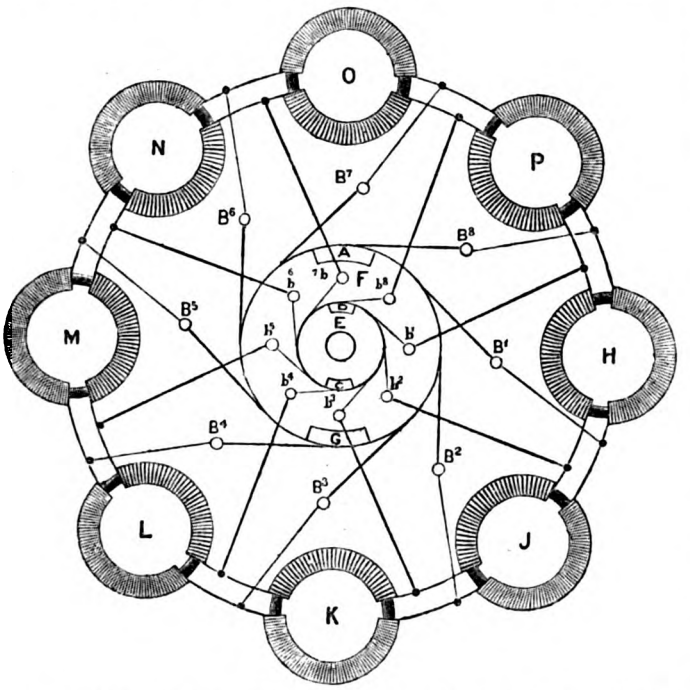

FIG. 1.—Edison's Transformer System of Electrical Distribution. Arrangement of Induction Coils and Commutating Alternator.

be reversed in the primary coils of O and K and induced currents generated in the secondaries of the same coils, which will be taken off by the brushes b^7, b^3, conveyed to two rings and thence

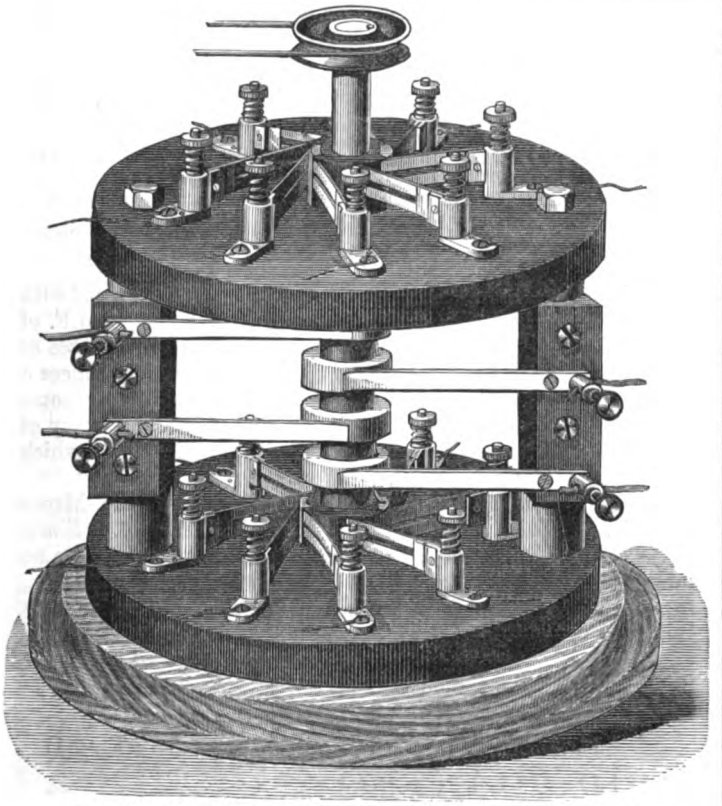

FIG. 2.—Edison's Alternator Used with his Transformer System.

by brushes to the local lamp or motor circuit. As the rotation continues the current in the primaries of the coils is in succession reversed and the induced current in the secondaries commutated. The transformers are connected in multiple arc with the dynamo circuit as shown, by the patent No. 278,418, May 29, 1883, a series system being extremely difficult of regulation. They may be described as a lot of closed magnetic converters arranged in a crown constituting a compound alternating and converting device, the commutation being obtained practically as in the coils of a Gramme ring. According to the ratio of the number of turns on the primaries and secondaries the electromotive force can be raised or lowered. For long distance transmission, using a continuous current of high tension, small conductors only are needed. This current is converted into a continuous current of low tension for incandescent lamp or motor circuits. Reversals of the current are made so rapidly (100-200 per second) that the percentage of conversion is remarkably high. If the primary coils be supplied with current of constant potential the apparatus is self-regulating, and the slight

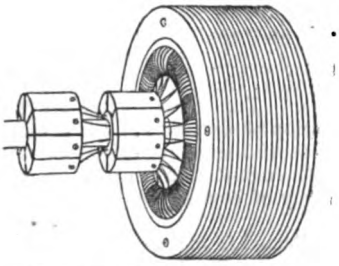

FIG. 3.—Rotation Transformer.

variation of the potential of the secondary circuit is due to the resistance of the wires. Less than the energy of one 16 candle-power lamp is required to operate a motor driving the rotating shaft to commutate current of 200 amperes.

Fig 3 represents a modification of this device. The primary and secondary coils are wound upon one iron core precisely as in a Gramme ring. Outside the whole is a mass of laminated iron, which is stationary, to concentrate the lines of force upon the copper wire. The primary coils of fine wire are connected with the commutator at the end of the shaft, and secondary coils of coarse wire with the remaining commutator.

The coils and shaft revolve. Brushes convey current to the primary coils, the current being reversed in each coil twice each revolution. The reversals of the induced currents in the secondary coils, occurring at the instant, the coil passes from left to right-hand side, as in a Gramme ring. The above device was patented on May 29, 1883, No. 274,418.

Mr. Edison's United States patent 265,786, dated Oct. 10, 1882,

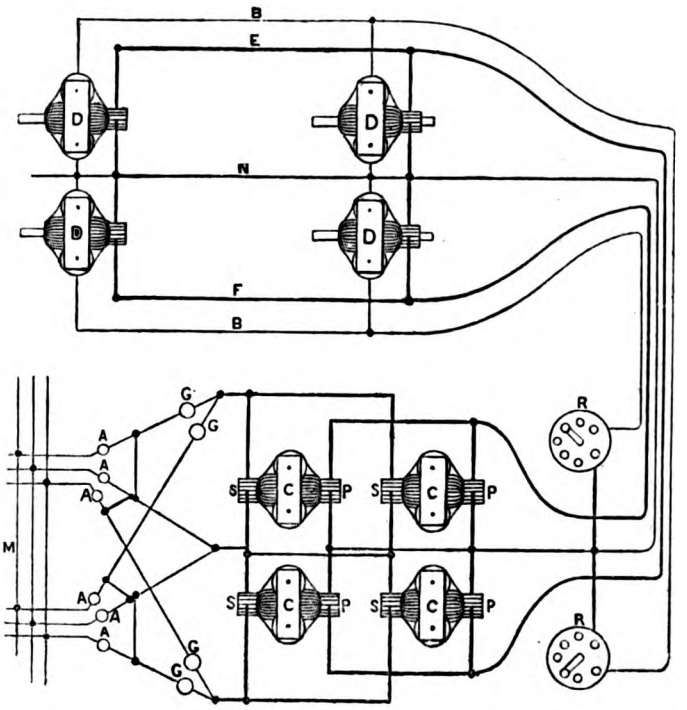

FIG. 4.—Edison's Plan of Rotating Transformers. The Primary Circuit Connected in Multiple Arc with the Dynamos.

describes a system for the distribution of electrical energy in which one set of armature coils of a number of the rotating transformers are connected in series with the dynamo supplying the current. In the secondary circuits of the transformers are placed incandescent lamps or other apparatus. By this system the expense

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for conductors on long circuits is materially reduced over that of low tension multiple arc distribution. Owing to the difficulties of regulation, Mr. Edison patented October 30th, 1883, No. 287,516, a system of electric distribution consisting of motor generators or transformers, the primary circuits of which were connected in multiple arc with the dynamo circuit, as shown in the diagram Fig. 4.

Dynamos D D D D, connected as usual in the three-wire system, are wound to generate currents of high electromotive force, admitting of the employment of small conductors. The three wires F, E, N, are connected at the sub-station with the primary circuits of the armature of the converters or transformers. The current for the field-magnets of the dynamos passes through the wires B, B, the rheostats R, R, which are at the sub-station, returning over the neutral wire N. The wires B are very small, preferably of iron for economy, and the slight loss of energy in them is of no consequence compared with the convenience of regulating from the sub-station the potential of the current supplied to the converters. The three-wire system is advantageous because the insulation of dynamos and converters will be subjected to one-half the potential of a two-wire system, and because the distribution from the sub-station is easily made on the three-wire system, and economy of conductors and increased area of distribution obtained.

The current is collected from the commutators SS, of the secondary coils of the converters, and is distributed exactly as if the armatures of the converters were driven by an engine instead of a current of electricity from a distant source.

From the indications of the ammeters A and voltmeters attached to pressure wires leading from desirable points on the distributing mains, the attendant at the sub-station regulates the potential of the distributing mains M by the feeder regulators G, and the rheostats R. By the use of the latter it is unnecessary to run back pressure wires from the sub-station to the dynamo station.

The armatures of the transformers or motor generators are wound with two sets of coils, large and small. As their names indicate, they are electric motors, the converting armatures revolving in a powerful field, by the influence of the current passing through their primary circuits. This disposition proves a potent factor in the economy of the system. As there is no belt strain, well-balanced armatures are run at double the speed of a dynamo of the same size. The output is therefore twice that of a dynamo of the same size. At an outlay of 50 per cent. of the cost of the dynamos of the central station, converters can be placed in a sub-station and current distributed four miles instead of less than a mile from the power plant, and at no greater expense for conductors.

The motor generators require much less attention than a dynamo with well balanced armatures; the weight alone of these causes any friction on the bearings. The number of amperes [? ampere turns] of the high and low tension circuits of the armature is approximately the same (any tendency to distort the lines of force and cause a rotation of non-sparking point in a negative direction by the high tension or motor coils is neutralised by the current flowing in opposite direction) of low tension or dynamo coils. There is absolutely no sparking at the brushes of either commutator, and the brushes, when once adjusted, require no change for any variation of load.

ON THE LOCALISATION OF A COMPLETE FRACTURE IN A SUBMARINE CABLE BY BRIDGE MEASUREMENT TO INSTRUMENT ZERO.

BY A. E. KENNELLY.

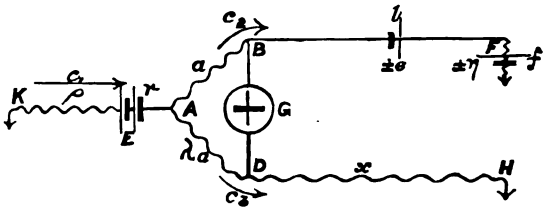
In localising the defect in a broken cable, certain measurements of a resistance $l+f$ have to be made at the testing station, where l is the resistance of the line of conductor between the testing station and fracture, and f is the resistance of the fracture itself. Thus l is the unknown constant quantity required to be determined, and f is a variable quantity which we shall assume to vary inversely as the square root of the current strength traversing it. In common with all circuits of which the earth forms part, l will contain a natural E.M.F. which we may denote by $\pm e$, and the exposed conductor at the fracture will offer an E.M.F. of polarisation we may denote by $\pm\eta$ set up at its surface by the passage of currents, so that $l+f$ has to be measured while containing the total E.M.F. $\pm(e\pm\eta)$.

Two methods are in general use for measuring $l+f$ under these circumstances with a Wheatstone bridge—one, Mance's method, by balancing the cable to true or instrument zero so that no current passes through the galvanometer while the testing current flows; the other by balancing to "false zero" so that the same current shall pass through the galvanometer during the flow of the testing current as after its cessation.

Mance's method employs two measurements of $l+f$ affected with $\pm(e\pm\eta)$ under two different bridge ratios, and yields $l+f$ from these by calculation. It has the advantage of being a "null method," and of being therefore susceptible of greater accuracy in balancing, as the full sensibility of the galvanometer can by means of a short circuit key be utilised. It also needs less manipulative skill. On the other hand, the "false zero" method has the advantage of yielding $l+f$ directly without calculation when such balance has been attained that the insertion or removal of the testing battery produces no alteration in the galvanometer's deflection beyond momentary electrostatic effect.

By causing the testing battery to send different known strengths, not exceeding 25 milliamperes of negative current, through the cable, and observing the change in the corresponding values of $l+f$ to false zero, the value of f can be eliminated and hence l determined with greater or less accuracy. It has therefore been suggested that by observing the strength of current sent to line in the two measurements of Mance's method, the value of f might be similarly eliminated and the quantity l more or less directly calculated. We propose to show that no single pair of Mance measurements can supply the data necessary for the elimination of f, even though the strength of current traversing f be known, and that three such separate measurements are required; but that the lengthy form which the equation evolving l then takes, renders it advisable to alter the current strengths to line, not by changing the bridge ratio coils, but in a determinate manner by the aid of a rheostat in the battery circuit, an arrangement which admits of a simple arithmetical solution to the formula.

We may observe that it is impossible to apply any secondary calculation to the Mance determination of $l+f$ for the purpose of eliminating f, because an inaccuracy exists in the Mance formula, which, without interfering with, but perhaps even enhancing, its practical value for arriving at $l+f$, would nevertheless defeat attempts otherwise indefeasible for subsequently arriving at l.



In the figure the line BF represents a cable of resistance l with a fracture at F, whose resistance is f and whose E.M.F. of polarisation is $\pm\eta$. There is also an E.M.F. in the cable of $\pm e$. AB and AD are the arms of the bridge of resistances a and λa respectively, where λ is generally unity or some power of 10. Connected to A is the zinc pole of a battery of E.M.F. E and resistance r, in circuit with a resistance ρ which is capable of being adjusted.

We shall now briefly follow the evolution of the Mance formula, and in so doing assume that $\lambda=1$ and $\rho=0$. Since, when balance is obtained, no current flows through G, then, no matter what $\pm(e\pm\eta)$ may be, the current c_2 must be equal to c_3, for the points A and B in the circuit ABF have respectively the same potentials as the points A and D in the circuit ADH, and are separated by equal resistances. Let c_2 and c_3 each be denoted by c, then the current in the battery circuit AK mus be $2c$. Then, by Kirchoff's laws—

$$2cr+c(a+x)-E=0 \qquad \therefore c(2r+a+x)=E. \quad (1)$$

$$c(a+l+f)-c(a+x)\mp(e\pm\eta)=0$$

$$\therefore c(l+f-x)=\pm(e\pm\eta) \quad . \quad . \quad . \quad (2)$$

Combining (1) and (2)

$$E(l+f-x)=\pm(e\pm\eta)(a+2r+x). \quad . \quad . \quad (3)$$

By now altering the ratio coils from $\frac{a}{a}$ to $\frac{b}{b}$, and repeating the balance to y instead of to x, we have on the assumption that

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f, $\pm e$, and $\pm\eta$ are unaltered, a similar equation—

$$E(l+f-y) = \pm(e\pm\eta)(b+2r+y), \quad . \quad . \quad (4)$$

and the current in the cable is now altered from $\frac{E}{a+2r+x}$ to $\frac{E}{b+2r+y}$ by equation (1), or from c to nc where $n=\frac{a+2r+x}{b+2r+y}$, so that we may write equation (4) thus:—

$$nE(l+f-y) = \pm(e\pm\eta)(a+2r+x). \quad . \quad (5)$$

Then, from (3) and (5) $l+f=\frac{ny-x}{n-1}$ . . . . . (6)

$$=y-\frac{d}{n-1} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where d is the difference $(x-y)$.

If we substitute for n its full value stated above, equations (6) or (7) become $l+f=\frac{x(2r+b)-y(2r+a)}{y+b-a-x}$ . . . (8)

which is the ordinary expression of the Mance formula.

But since the current flowing through f is different in the two measurements, the assumption in equation (4) that f has the same value in both is inaccurate, for the resistance of the fracture being f in the first measurement, will by the law of inverse square roots be $\frac{f}{\sqrt{n}}$ in the second measurement. Suppose a greater than b, then $n>1$ and we shall have $x>y$. Therefore, d is a positive quantity, and the resistance $\frac{f}{\sqrt{n}}$ of the fracture entering into y is less than f entering into x. On this account d will be greater than if f were constant, and equation (7) shows that an excess in the value of d makes $l+f$ in the calculated result too small. That is to say, the calculated value of $l+f$ will be less than the actual sum of cable and fracture in the second measurement, and *à fortiori* still less than the actual sum in the first.

By writing equation (5) more strictly we have

$$nE\left(\frac{f}{\sqrt{n}}+l-y\right) = \pm(e\pm\eta)(a+2r+x). \quad . \quad . \quad (9)$$

whence with (3) $f=\frac{(y-l)(n-1)-d}{\sqrt{n}-1}$ . . . . (10)

and $l+f=\frac{ny-x}{\sqrt{n}-1}-l\sqrt{n}$ . . . . (11)

For example, Sir Henry Mance, in the paper on his method read before the Society of Telegraph-Engineers and Electricians, May 8th, 1884, gives, among others, the following case (*vide Society's Journal*, Vol. XIII., No. 53, page 339):—

$x=421$ $y=392$ $a=950$ $b=95$ $r=200$ $l=351$.

By the Mance equations (6) (7) or (8) with these values

$$l+f=363;$$

but substituting the same values in equation (11), and with $n=\frac{a+2r+x}{b+2r+y}=\frac{1771}{887}$, we have

The more accurate value of $l+f$ in measurement

No. (1) was 379·8ω

" " " " " No. (2) was 371·4ω

Thus, the fracture probably offered 29ω in one case and 20ω in the other, while by the Mance formula it offered 12ω in both.

As already mentioned, the theoretical discrepancy in the Mance formula is no argument against the practical value of the Mance method aiming at $l+f$ only, for since it may be shown that this discrepancy can never practically reach the true value of f, the consequence is simply that less resistance has to be allowed for f in employing Mance's method than in any other except Lumsden's in particular instances.

In the case just worked out we have been able to arrive at f and $l+f$ only because l was given, for had l not been stated there are no means of arriving at these quantities from two measurements only, as we can prove later on. If, however, a third Mance measurement be taken with a bridge ratio $\frac{c}{c}$ and a balance of z, so that the current through the fracture is increased to mc where $m=\frac{a+2r+x}{c+2r+z}$, then we have by symmetry an equation like (9)

$$mE\left(\frac{f}{\sqrt{m}}+l-z\right) = \pm(e\pm\eta)(a+2r+x) \quad . \quad (12)$$

e and η are assumed to remain constant through all three measurements. From (3) (9) and (12) we have

$$l=\frac{(mz-x)(\sqrt{n}-1)-(ny-x)(\sqrt{m}-1)}{(m-1)(\sqrt{n}-1)-(n-1)(\sqrt{m}-1)} \quad . \quad (13)$$

and if $x-z=D$ and $y-z=d$

then $$l=z-\frac{nd(\sqrt{m}-1)-D(\sqrt{m}-\sqrt{n})}{(m-1)(\sqrt{n}-1)-(n-1)(\sqrt{m}-1)} \quad . \quad (14)$$

The last equation supplies the value of l in terms of z and the differences between the balances, together with the ratios n and m, which are found from the equations

$$n=\frac{a+2r+x}{b+2r+y} \text{ and } m=\frac{a+2r+x}{c+2r+z} \quad . \quad . \quad (15)$$

n being greater than unity and m greater than n, or, in other words, the weakest current flowing in the first measurement and the strongest in the third.

Referring again to Sir Henry Mance's paper, we may take the two cases recorded on page 341, where in the first instance

$a=1{,}000$, $b=100$, $c=10$, $x=130$, $y=51$, $z=42$, $r=6$,

whence $n=7{\cdot}006$, $\sqrt{n}=2{\cdot}647$, $m=17{\cdot}844$, $\sqrt{m}=4{\cdot}224$;

in the second instance

$a=1{,}000$, $b=100$, $c=10$ $x=77$, $y=43$, $z=49$, $r=20$,

whence $n=6{\cdot}104$, $\sqrt{n}=2\,471$, $m=12{\cdot}551$, $\sqrt{m}=3{\cdot}543$.

These values inserted in equation (14) yield $l=34\omega$ in both cases. The actual value of l is stated to have been 24ω.

Formula (14) is, however, too lengthy for general use when time cannot be afforded for arithmetical solution, and unless l be small the balance with a ratio of $\frac{10}{10}$ could not generally be observed with much accuracy. Instead, then, of observing to true zero with three different ratios, we will consider the case of keeping one suitable ratio and observing three balances with different resistances in the battery circuit. We shall see that this case is reducible to formula (14), and by treating it generally we shall show that three measurements are required for the determination of l.

Referring to the figure we will assume the bridge ratio fixed at $\frac{a}{\lambda a}$ and the testing current altered by altering ρ.

Let ρ_1 be a certain resistance which will enable a current c to flow to line, and let the resistance of the fracture to this current be f.

Then, because in the circuits A B F and A D H the points A and B have, when balance is obtained, the same potentials as the points A and D respectively, while the resistance separating A and D is λ times that separating A and B, the current c_2 in A B F must be λ times the current c_3 in A D H, so that if the current $c_2=c$ then $c_3=\frac{c}{\lambda}$, and the current c_1 in the battery circuit A K will be $c\left(\frac{\lambda+1}{\lambda}\right)$. Under these circumstances let x be the balance observed. Then let ρ_1 be a certain resistance which will enable a current nc to follow to line, and let the balance observed be y. Then we have

$$\left(\frac{\lambda+1}{\lambda}\right)c(\rho_1+r)+\frac{c}{\lambda}(\lambda a+x)-E=0 \quad . \quad . \quad (16)$$

$$c(a+l+f)-\frac{c}{\lambda}(\lambda a+x)\mp(e\pm\eta)=0 \quad (17)$$

$$n\left(\frac{\lambda+1}{\lambda}\right)c(\rho_2+r)+\frac{nc}{\lambda}(\lambda a+y)-E=0 \quad . \quad . \quad (18)$$

$$nc\left(a+l+\frac{f}{\sqrt{n}}\right)-\frac{nc}{\lambda}(\lambda a+y)\mp(e\pm\eta)=0 \quad (19)$$

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From these equations, which contain all the data that Kirchoff's laws can supply, it is required to eliminate four quantities, namely, E, $\pm(e \pm \eta)$, c, and f, that is to say the same number of quantities as there are independent equations. Thus, two measurements do not yield sufficient data for the purpose. By taking a third, however, with ρ_2 reduced to ρ_3, thereby increasing the current to line from $n\,c$ to $m\,c$ and observing the balance z, we have

$$m\left(\frac{\lambda+1}{\lambda}\right)c\,(\rho_3+r)+\frac{m\,c}{\lambda}(\lambda\,a+z)-\mathrm{E}=0 \quad . \quad . \quad (20)$$

and $$m\,c\left(a+\lambda+\frac{f}{\sqrt{m}}\right)-\frac{m\,c}{\lambda}(\lambda\,a+z)\mp(e\pm\eta)=0 \quad (21)$$

We have now six equations involving five unknown quantities, and by combining them we obtain

$$l=\frac{1}{\lambda}\left\{\frac{(m\,z-x)\,(\sqrt{n}-1)-(n\,y-x)\,(\sqrt{m}-1)}{(m-1)\,(\sqrt{n}-1)-(n-1)\,(\sqrt{m}-1)}\right\} . \quad (22)$$

This equation coincides with (13) if $\lambda=1$, but when λ is not unity we have

$$l=\frac{\left(\frac{m\,z}{\lambda}-\frac{x}{\lambda}\right)(\sqrt{n}-1)-\left(\frac{n\,y}{\lambda}-\frac{x}{\lambda}\right)(\sqrt{m}-1)}{(m-1)\,(\sqrt{n}-1)-(n-1)\,(\sqrt{m}-1)} \quad . \quad (23)$$

So that if x y and z are divided by λ before being recorded, equation (23) coincides with (13), namely,

$$l=\frac{(m\,z-x)\,(\sqrt{n}-1)-(n\,y-x)\,(\sqrt{m}-1)}{(m-1)\,(\sqrt{n}-1)-(n-1)\,(\sqrt{m}-1)} \quad . \quad . \quad (24)$$

and (14) follows

$$=z-\frac{n\,d\,(\sqrt{m}-1)-\mathrm{D}\,(\sqrt{m}-\sqrt{n})}{(m-1)\,(\sqrt{n}-1)-(n-1)\,(\sqrt{m}-1)} \quad . \quad (25)$$

Thus l is solved in terms of x y and z, also m and n. By causing m and n to assume certain determinate values, equation (14) and (25) takes simpler forms.

Thus if $n=4$ and $m=9$ $\quad l=z-4\,d+\frac{\mathrm{D}}{2}$ . . . . . (26)

If $n=2{\cdot}25$ and $m=16$ $\quad l=z-\frac{9}{5}d+\frac{2\mathrm{D}}{3}$ . . . . . (27)

If $n=4$ and $m=16$ $\quad l=z-2\,d+\frac{\mathrm{D}}{3}$ . . . . . (28)

If $n=2{\cdot}25$ and $m=4$ $\quad l=z-9\,d+2\,\mathrm{D}$ . . . . . (29)

It would of course be possible to enforce these values of n and m by inserting a galvanometer or potentiometer in the line circuit ACF; but this is unnecessary, because we have always

$$n=\frac{(\lambda+1)\,(\rho_1+r)+\lambda\,a+x}{(\lambda+1)\,(\rho_2+r)+\lambda\,a+y} \text{ and}$$

$$m=\frac{(\lambda+1)\,(\rho_1+r)+\lambda\,a+x}{(\lambda+1)\,(\rho_3+r)+\lambda\,a+z} \quad . \quad (30)$$

Consequently to give n and m determinate values, we have (on the assumption that e and η are constant)

$$\rho_2=\frac{\rho_1}{n}-\left(\frac{n-1}{n}\right)\left(r+\frac{a\,\lambda}{\lambda+1}\right)-\frac{1}{\lambda+1}\left(y-\frac{x}{n}\right) . \quad (31)$$

and $$\rho_3=\frac{\rho_1}{m}-\left(\frac{m-1}{m}\right)\left(r+\frac{a\,\lambda}{\lambda+1}\right)-\frac{1}{\lambda+1}\left(z-\frac{x}{m}\right) . \quad (32)$$

In these equations the first two of the three terms on the right hand side are fixed by the first measurement, and x y z must be inserted undivided by λ, not as in equations (25) to (29). If $\lambda=1$, these equations take the following forms:—

With formula (26)
$$\rho_2=\frac{\rho_1}{4}-\frac{3}{4}\left(r+\frac{a}{2}\right)-\left(\frac{y}{2}-\frac{x}{4}\right) . \quad (33)$$

$$\rho_3=\frac{\rho_1}{9}-\frac{8}{9}\left(r+\frac{a}{2}\right)-\left(\frac{z}{2}-\frac{x}{18}\right) . \quad (34)$$

With formula (27)
$$\rho_2=\frac{4\,\rho_1}{9}-\frac{5}{9}\left(r+\frac{a}{2}\right)-\left(\frac{y}{2}-\frac{4x}{18}\right) . \quad (35)$$

$$\rho_3=\frac{\rho_1}{16}-\frac{15}{16}\left(r+\frac{a}{2}\right)-\left(\frac{z}{2}-\frac{x}{32}\right) . \quad (36)$$

and similar forms with formulæ (28) and (29).

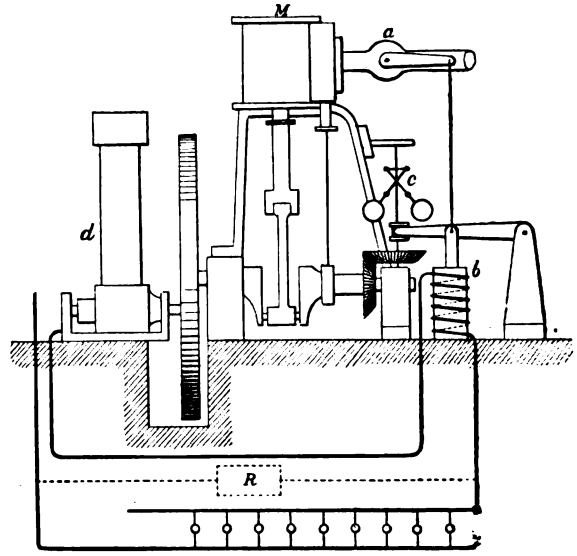
Thus, having satisfactorily observed x with ρ_1, the two first terms of (31) will give a trial value of ρ_2, and generally a single re-adjustment of ρ_2 for the third term will give n with all desirable accuracy when balance is obtained. Similar steps have then to be taken with m and z.

(To be continued.)

MENGES' ELECTRIC GOVERNOR.*

In all installations variations in the output required are unavoidable; sometimes many lamps are on, sometimes few, and various attempts have been made to overcome the irregularities due to these variations by means of electrical governors. Those at present in use, however, only come into action when the change in the quantity to be kept constant (C or E) has already begun to take place. In these the regulator is placed in the circuit in which the current is to be kept constant. If E is to be kept constant, then the current in a shunt of constant resistance must remain the same, and the regulator is placed as a shunt on the main circuit, as at R (while for a constant current system the regulator would be in the main circuit).

In the author's system the converse is the case. To save time, an example of the system for parallel working is given.



The dynamo is supposed to be a simple shunt and regulated by varying the speed; any regulator at present in use would be introduced in shunt at, say, R, and open or close the throttle-valve a according as the current through it is too weak or too strong. It is clear, however, that better regulation would be obtained if, instead of the change affecting the regulation, the cause of change could be made to do so—if, for example, each lamp switch were so connected with the throttle valve that turning the lamp on or off opened or closed the valve a little.

A direct mechanical connection would be impracticable, but an electrical one answers the same purpose. When a lamp is turned on the main current at once increases, and if a solenoid, b, with a soft iron core, be introduced in the main circuit, then the attraction between the two will increase by a definite amount when a lamp is switched on.

If the core be now counterbalanced by a spring, counterweight or other means, so that the core takes up different positions for different current strengths, then cutting a lamp in or out will cause a simultaneous corresponding movement of the core in b. If then the core be connected to the throttle valve, it will have the same effect as if each separate switch were mechanically connected thereto.

By properly arranging the dimensions of the solenoid, core, &c., it may be arranged that the position of the valve shall, according to the number of lamps on, vary speed for the engine and dynamo, so as to maintain constant E.M.F. (The author, in a foot-note, says that very little "hunting" is found to take place.)

The same apparatus may be arranged to keep the speed of a compound dynamo constant, and is even more efficacious for

* Abstracted from the *Electrotechnische Zeitschrift*.

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this purpose. As in the former case, it requires a certain lapse of time to alter the speed, whereas for constant speed this is obviously not the case.

Since this method is actuated only by changes in the output and not by variations in the driving power, it is generally advisable to use it in conjunction with an ordinary centrifugal governor. The simplest way is to connect the two as in figure. If the position of the core in the solenoid be so chosen that the attraction is only slightly altered by a small displacement, then the weight and attraction of the core act as an additional weight on the governors, the working of which is not appreciably prejudiced thereby.

The author mentions the use of the apparatus at the Elec. Tech. Laboratory of the Hochschule at Berlin, where it was applied to a Siemens compound, worked off an 8 horse power gas engine. It was practically arranged as in the figure, and simply attached to the governor lever by a hook, so that it could be put on or off as desired. Speed was measured on a Buss-Sombart tachometer. With the centrifugal governor alone the variation in speed between full load and running light was about 10 per cent. With the electrical governor in action, there was no difference visible on the tachometer. The apparatus may equally well be used to throw resistance in and out of the field-magnet circuit, instead of acting on the throttle-valve.

In the same way the governor may be used to keep the current constant in a series arc-lamp circuit; in this case it is put in as a shunt across the machine terminals.

With regard to the solenoid and core the author remarks that, under certain circumstances, a somewhat complicated mechanical motion may be necessary. It might be suggested that in such cases an arrangement similar to those in use in the ordinary electrical governors might be employed. On closer inspection, however, this is found not to be so. In his apparatus the moving part (the core) takes up a distinct position for each particular current strength, whilst in other regulators the moving part is at rest only for one strength of current in its actuating coil, and is always in movement until this current is obtained.

The governor does not pretend to completely prevent slow changes, such as are due to warming of the wire on the dynamo, but to counteract sudden changes, which are of necessity constantly occurring, such as are caused by switching lamps on or off, throwing motors in or out of work, stopping or starting electric tram cars, &c.; for all such purposes this arrangement is claimed to be by far the best.

The author then makes some remarks on other means of regulating apart from governors, such as Ayrton and Perry's, Edison's, and compound-winding. The author's aim was to make a regulator which should have the same effect on a dynamo as compound-winding, *i.e.*, regulation preventing irregularities caused by variations in the output, counteracting every irregularity as soon as the first cause was present.

He lays particular stress on the fact that he has obtained complete regulation for changes due to variation of load, not by any complicated arrangements, but by the simple one shown in figure, which, as far as his governor is concerned, is not merely a theoretical diagram but an actual sketch of the whole governor mechanism. Besides the Berlin tests the author mentions that he has tried it experimentally in his laboratory, and has recently obtained perfectly constant E.M.F. in a shunt machine.

With compound winding a perfectly straight line for the curve of E.M.F. is seldom obtained. If, however, the author's regulator be used to vary properly chosen resistances in the field-magnet circuit of a shunt machine, instead of acting on the valve, a perfectly straight E.M.F. curve can be obtained, or even any other form of curve desired.

This method is particularly important for regulating constant current, as for this purpose compound winding is not generally of easy application. As before mentioned, in this case the solenoid B must be in shunt on the main circuit, the series machine being regulated by varying the number of turns on the field-magnet.

This regulator has, under certain circumstances, advantages over compound winding, even when the latter is sufficient so far as regulation goes. In case of a short circuit on the line, compound winding allows the armature to be burnt out. In a simple shunt it is not so. The regulation is in practice just as quick and exact as compound winding, for the core, being so much smaller, changes far quicker in magnetism than the heavy field-magnets. As a final advantage, the author points out that it is a method which can be readily applied to any existing machine.

UNDERGROUND CONDUCTORS FOR ELECTRIC LIGHTING, &c.*

BY PROF. GEORGE FORBES, M.A., F.R.S.

The author has designed the proposed system to fulfil several important conditions:—

1. The conductors and their insulation should be economical in construction.

2. They should be protected from injury by a trough or casing.

3. This trough should be of small cost and its merits must have been well tested.

4. The trough must be capable of carrying conductors at several different potentials.

5. It must be possible gradually to add to the conductors as the consumption of electricity in a district increases.

6. An easy means must be provided for taking branches from the mains into houses.

7. An easy means must be provided for leading the conductors round gas and water pipes and other obstacles.

The first condition can best be secured by having bare copper wire conductors and air insulation.

The second and third conditions by using ordinary cast-iron gas pipes, whose qualities are thoroughly well known, and whose laying and repairing and keeping watertight is every day work in every town in the country.

The fourth condition is attained by having porcelain insulating discs, two in each cast-iron pipe. Each insulator has as many holes through it as there are different potentials to be maintained. These porcelain discs are supported on the iron pipes only at a few points, the intervening spaces allowing drainage in the cast-iron pipes, and also permitting dry air to be forced through a system of pipes.

The fifth and sixth conditions are attained by the special peculiarity of this invention, which consists in using thin split copper tubes with a quarter-inch gap at the split. These are each six inches longer than one of the iron pipes. By pinching the end of one of these tubes and inserting it into the end of another, and continuing the process, a long continuous tube can be made for carrying the bare copper-wire conductors. These continuous tubes pass through the holes in the insulators. The number of copper wires can be added to as the requirements of a district increase. When two-thirds full, these wires are all withdrawn and a bare wire cable filling the whole space of the tubes is drawn through. The wires are drawn through from manhole to manhole. A manhole is placed at each corner of a street; and serves also as a sump for pumping out accumulations of water. When it is required to connect a house to the mains, the iron pipe is drilled and tapped with a one-inch hole. Insulated wires are soldered to the copper tubes of the required potentials, and are led to the houses through inch gas-pipes which are screwed into the hole tapped in the cast-iron pipes. It will be noticed that the split tubes do not act primarily as the conductors of the main current, but mainly as a support for the conductors and secondarily, by contact with these, as a means of connection to the houses, leaving the wires free to be removed or added to.

The seventh condition is to provide for getting round an obstacle. This is best done by having a hand-hole at the ends of the cast iron pipes on each side of the obstacle and joining these by lead-covered insulated cables of the full current-

* Paper read before the British Association Meeting at Manchester, September, 1887.

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carrying capacity of the system. These cables can be bent round the obstacle, and are in no way a weak point of the system.

The method of laying the conductors in the ordinary routine is as follows:—For a three-wire system for a maximum of 2,000 lamps of ¾-ampere, a 3in. gaspipe may be used. Each insulating disc has three 1in. holes in the positions of the angles of an equilateral triangle. In adding fresh lengths of conductor, three split tubes are first pinched at their ends and pushed into the ends of the three split tubes projecting from the last cast-iron pipe laid. Two insulators are next run along the split tubes to a distance from either end of the tubes of one-fourth of their length. A fresh cast-iron pipe is now run along over the split tubes and their insulators, the latter fitting loosely in the pipes. The joint of the pipes is made with packing in the ordinary way. A new length is added in the same way. Manholes must be placed at each corner of a street, and may be half a mile apart. The cast-iron pipes fit into side holes in these boxes, and are fitted in with watertight cement or packing. Wires are pulled through from manhole to manhole, and may be soldered together across the manhole. Finally, holes are drilled and tapped in the cast-iron pipes beside those houses which require a supply of electricity. Two insulated wires, bared and flattened at their ends, are soldered to those split copper tubes which are of the right potentials. A 1in. gas pipe is screwed into the hole tapped in the main pipe, and the insulated wire is thus led into the house.

DISCUSSION.

Mr. UPTON desired to ask whether the tubes expanded by heat, and what, if any, provision had been made to keep them from buckling?

Mr. PREECE thought it would be of advantage to the section if Mr. Upton, who had had a great deal of experience in America in carrying out electric lighting installations, would give them a little information as to the practice adopted in New York.

Mr. UPTON said that the practice of the Edison Company in New York was the only one with which he was familiar, and it consisted in laying a wrought-iron tube in which in the present three-wire system were placed solid conductors, the tube being then filled with insulating material. The great difficulty that arose in his mind as to the joint in the side of the tube, as exhibited by Prof. Forbes, was that the attachment must be made when the current was passing through. The E.M.F. was present, and unless the workmen could get at and see what they were about they were very much frightened, because when they put 1,000 horse-power across those wires it simply meant a volcano. They had no idea of the amount of power that would come out of the opening.

Prof. FORBES: How do you make your connections?

Mr. UPTON replied that they were all open in a vessel or chamber. The workman saw what he was about An air current was kept running through the whole pipe. In New York city there were some 17 miles of underground tubing made since 1880, and the current was never broken to make the attachments, which were made at the end of the pipes. The give of the joints afforded the necessary expansion. In the Edison system, instead of using, as in this case, porcelain insulators, the wire was wrapped round with long spirals of rope, which held the wires mechanically apart, and everything is put into the tube, attached to a vacuum pump, so that everything was kept dry, and then the insulating material was drawn in, making a very high insulation. He thought that the system exhibited was meant for alternating currents.

Prof. FORBES: Not in the least—for every kind.

Mr. UPTON: The only point that struck me was the difficulty of taking in large wires.

Prof. FORBES: I do not want large wires I sub-divide and use small ones.

General WEBBER thought that apart from other remarks that might be made upon the system proposed by Prof. Forbes, there was one circumstance that appeared to him to be a novel departure to those who were well acquainted with such an arrangement as this system of insulating conductors, and that was the insulation of the conductors by porcelain or other non-conducting materials. Another departure was the use of split tubes, through which the conductor proper was supposed to be drawn. He could not himself quite see the necessity of those split tubes, except as a guide for the copper conductor, which was drawn through them—that was to say, in and out as the case might be—and he did not think himself that the practical result would produce any great convenience. There was one point on which he thought Prof. Forbes would agree with all those who had had any experience in the laying down and maintenance of underground conductors, and that was that wherever there was a joint there must be a box for access to it.

Prof. FORBES explained that the object of the split tubes was only to make a channel, which would be more or less filled. Its chief advantage was that they were thereby enabled to alter the number of wires in the conductor according to their system. The attachments to the houses did not fix them, and they were therefore capable of being drawn in and out.

General WEBBER said that in that case each split tube had a separate wire for a conductor.

Prof. FORBES: And a means of connection with the mains.

General WEBBER: So that there will be a loose contact of the sides which will make a connection between branches?

Prof. FORBES: Yes.

General WEBBER said that one naturally laid great stress upon the desirability of having a box for access to every place where there was a joint, and without in any way offering criticism on the practical result of the system, he thought that if Prof. Forbes would allow in his system a means of drawing in and out the wires, and also that there should be a box for access at every joint of contact, he did not see that it mattered very much what detail of system was adopted.

Mr. SCHOOLBRED remarked that generally the split tubes formed, if even a minimum, a portion of the conductors themselves.

Prof. FORBES: Of course they do to a certain extent, but I simply do not depend upon them.

Prof. SILVANUS THOMPSON wanted to know how the lineman got access to the hole in order to solder the wires on to the tubes inside. There seemed to be a doubtful chance of his making a good joint.

Mr. R. P. SELLON wished to ask Prof. Forbes whether in a large ramified system of so many miles of piping of this kind, with manholes at every other point, it was really possible to keep mud and water out of the system, as otherwise there might be an unpleasant experience of the volcano which Mr. Upton had just spoken of?

Colonel HERSCHELL thought that a little explanation would be advisable as to the connection round obstacles. How was the insulated portion attached, and to what was it attached?

Mr. LAW said that with regard to the observation that had been made as to the difficulty of soldering the wire, he was inclined to think that though there might certainly be a difficulty it might easily be obviated by some simple mechanical arrangement.

Prof. FORBES said he would endeavour to explain the several points raised. Having regard to the time of the section, he was afraid that he had been a little too rapid in his description of the system. Mr. Upton asked what allowance was made for the expansion of the tubes by heat. The very fact that they were simply loosely in contact, that they were made to be and put into contact by pinching one and putting it into the other, left ample room for expansion. There was no difficulty on that account, and the wires which they contained being, as had been explained, thin wires, they were perfectly able to expand without doing any damage, which would be done if, as Mr. Upton had imagined, thick, solid wires were to be passed through them. He might say that the only piping which could not expand was a totally different thing, and that was gas piping. It could not expand, but according to the proportions which had been given the temperature to which the iron piping could be raised was insufficient to produce such an expansion as to weaken the ordinary gas joints. General Webber had asked a question about the split tubes, but he (the speaker) thought the gallant General had misunderstood him. In a great portion of his remarks General Webber seemed to think that the sole object of the split tubes was to be the conductor of the whole current, and therefore very rightly said that the joints were not good enough, and also that there ought to be a box at each joint. He would naturally have boxes for access at points where there were joints of the wires inside the split tubes, and, say, at the corners of streets. Prof. Thompson had asked how the joints were to be soldered. The speaker had worked upon that, and had had a great many experiments before he succeeded in effecting it satisfactorily; but he should have thought that any practical man would have seen the possibility by means of specially designed tools of getting over the difficulty. One thing greatly simplified it. The fact was that he flattened the wire where the joint had to be made, and by the aid of very simple tools there was practically no difficulty in soldering. As to Mr. Sellon's question about keeping out moisture and mud, he could only refer that gentleman to Mr. Aird, who would be better able to answer the question than he (the speaker) could.

Mr. SELLON: Would you not get condensation, which would cause leakage across the porcelain pipes?

Prof. FORBES thought not. All that he could say was that in addition to the advantages that gas people had had they could by this system, while the temperature was at its maximum, force dry air through the tubes to remove all moisture.

Mr. UPTON said that pickholes had been a source of great difficulty experienced in practice in New York.

Prof. FORBES said that he had left that difficulty to be dealt with in the same way as gas pipe breakages were dealt with.

Mr. PREECE, in proposing a vote of thanks to Prof. Forbes for his valuable paper, hoped that the day was not far distant when Prof. Forbes would have an opportunity of making a practical test of the plan he had submitted to the section. He (Mr. Preece) was afraid that it would be found that the difficulties in actual practice would not be quite so easily surmounted as Prof. Forbes seemed to think. There were two questions to be considered. Mr. Sellon had raised one, and that was the condensation of moisture in the pipes. It happened that in the Post Office service they had a large system of air-tight pipes conveying by pneumatic power messages from one part of the city to another. There it was found that in the morning there was a very considerable accumulation of moisture indeed, so much so that special carriers had to be sent through every morning to carry away the quantity of water that had accumulated overnight, and it was often very considerable, and would undoubtedly bring the wires into contact. Another difficulty was with regard to the joints. In all electrical appliances, whether for telegraphic or telephonic purposes, electric lighting, or the transmission of power, the great secret of the successful working of a system was to be sure that they had absolutely perfect mechanical and electrical joints. They must also have their joints in such a position so as easily to get at them and thus secure perfect soldering. They could not do without soldering. It was not of the slightest use to trust to screws or anything of the kind. Another prac-

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tical difficulty in carrying out any system of the kind was that of meeting obstructions in the streets, such as cellers, sewers, gas pipes, &c. In laying a system of pipes through a town they had dodge a gas pipe here, a water pipe there, and a cellar somewhere else, so that they could not rely upon getting a straight line for their system of tubes. There was nothing so good as discussion on a new subject like this, as it brought out its weak points and enabled its author to set his mind to work to remove any objection that might be raised, which he had no doubt Prof. Forbes would be able to do.

A NEW FORM OF SECONDARY BATTERY.*

BY KILLINGWORTH HEDGES, MEM. INST. CIVIL ENGINEERS.

Secondary batteries or accumulators may be said to have become a necessity in private installations of the electric light, and to be as far advanced as any other part of the lighting system. The batteries which are best known are widely different from those designed by the original inventor, M. Gustave Planté, very little attention having been paid to this type until the matter was taken in hand by a French engineer, M. Phillimond Bailly, whose invention I shall have the honour of describing to you to-day. The battery, which has been termed the Phœnix, is of two kinds Pb-Pb, or lead-lead, and Pb Zn or lead-zinc, and it is to the latter to which I will confine my remarks. The idea of using zinc for the cathode or positive plate of a secondary battery is not new in principle, having been described by several inventors, but its adoption for commercial work was not practicable until about a year ago, when M. Bailly introduced this battery in several installations abroad, where they are still employed. M. Reynier had previously designed a battery with a lead or copper plate coated with zinc, but it failed, and long before this Mr. Swinburne tried a similar plan, employing oxide or carbonate of zinc; but both these arrangements were far more expensive than that of M. Bailly, who prepares his zincs by moulding zinc filings with mercury, and compressing it into a rod or plate.

In a lead-zinc battery the action is as follows:—The zinc plate is attacked by the sulphuric acid in the presence of the peroxide of lead, the latter acting as a perfect depolariser; consequently the reaction is much more energetic than in a lead-lead battery, and the available E.M.F. is, in fact, 2·5 volts, falling to 2·33 when current is taken out. A lead-zinc accumulator is, in fact, a perfect primary battery, in addition to having a large storage capacity, which M. Bailly has found to be five times as much as a lead lead battery with plates of similar surface. In discharging, the zinc plate dissolves in the dilute acid, forming sulphate of zinc, which is decomposed on re-charging, pure metallic zinc being deposited on the zinc plate. The zinc, if properly amalgamated, is thus never consumed, but only dissolved and re-deposited. I have on the table some zinc plates which have been used in a small portable battery which I have used nearly every evening for the past four months, and they are still quite fit for work, although they are simple strips of commercial zinc, and not made on M. Bailly's plan of moulded filings. If the latter is employed I do not see why the zinc plate should not last as long as the peroxide plate. The lead plates of the Planté cell were simple sheets of rolled up lead, and had very little capacity. In the Phœnix battery they are formed of a quantity of fine shreds termed "lead wool" which are interwoven among a number of strips or fringes cut out of a lead plate, so as to form a sort of basket work, which is submitted to pressure, and then placed in the space left between a porous pot and the outside receptacle. The object has been to have a solid metallic conductor permeating the whole mass of the lead wool, so as to pick up the current with a minimum loss due to internal resistance, which has been the cause of failure of those Planté batteries in which lead wool or spongy lead was employed. M. Bailly compares his mode of picking up the current to the "venous system of the human body," in that the main conductor or artery spreads out in every direction much in the same manner as the veins in the body. The capacity of lead plates constructed in this manner is very large, the lead wool giving a surface of 1·5 square metre per kilogramme of lead; every part of the mass is permeated by the fringe-like extensions of the conductor, which being of much larger section than the lead wool filaments remain firm and solid when the latter are completely peroxidised.

Lead-zinc batteries may be constructed in various forms; a convenient arrangement is the circular form which I designed with a view to strength and portability.

The zinc plate is contained in a circular porous pot, conical at the bottom so as to economise the mercury, which forms an excellent electrical connection between the copper conductors and the zinc, without the use of a soldered joint, and admits of the speedy removal of the zinc plate. In larger cells a flat zinc electrode is used, and is contained between two porous plates which are made of compressed sand and offer very little resistance to the current, because they are honeycombed in every direction, and are, in fact, too porous for primary batteries.

The outside case is made of celluloid, a material which is extremely useful for electrical purposes, in that it is unaffected by acid and can be readily moulded into any required shape; also it is much lighter than any other suitable material. For small cells I usually protect the celluloid by a wicker-work covering, but in the larger kind, when they have to be removed for charging, a very light and strong receptacle is made by placing the celluloid in a loose fitting wooden box, and running an insulating material between the two, which effectually takes off any jar that might injure the interior cell. I have found that the most suitable material is a compound known as Phœnix varnish, in that it is almost as cheap as pitch and does not shrink or crack at a low temperature.

A disadvantage attending the use of a lead-zinc battery has been often quoted, namely, that there is a greater fall of electromotive force than with a lead-lead couple. This is not a serious objection, even for lighting purposes, if the discharge is not pushed too rapidly; for driving motors, electrical welding, and other new methods to which secondary batteries may be applied, a fall of electromotive force is of little consequence, and is more than compensated for by the gain of nearly 25 per cent. in the E.M.F. M. Bailly states that he has obtained an output of nearly five times as much from a lead-zinc battery of similar surface to a lead-lead without lowering the E.M.F. below two volts; he has also obtained 28 ampere-hours per kilogramme of peroxidised plate, or 0·08lb. per ampere-hour. In practice I have not obtained so good a result, the average output being 0·13lb. per ampere-hour, which, however, compares very favourably with other batteries.

In the early days of accumulators it was seriously proposed to distribute electricity by their use in the same manner as milk. The all-important factor of the difference in weight of the empty milk cans—as compared with the empty batteries—was apparently forgotten, and the public quickly found this out, although there is a story that a railway company were satisfied with the statement that a set of batteries were empty, and, therefore charged the carriage at the returned empty rate.

It would not, however, be impracticable for a few people living in the same neighbourhood to arrange to take a supply of electricity for lighting their principal rooms, as a small set of batteries on the plan I have here could be easily delivered.

This basket contains six cells or bottles, the total weight being under 1cwt., so that the whole can be carried by one man. The capacity of each cell is 60 ampere hours, and a sufficient number of lamps can be maintained to light a dinner table.

There is a great want at the present time for a small portable battery for railway carriage lighting, to be used as a reservoir for maintaining the lamps when the carriages are uncoupled for the purpose of making up the train. The successful illumination of railway trains by electricity has been practically demonstrated by the North-Western and other companies, who have had trains electrically lighted for some years. The plan which appears to give the best results is to fix a small dynamo and high-speed engine either on the locomotive or back of the tender, giving the driver control of the apparatus, so that he can readily start it from the foot plate. The only objection has been the impossibility of disconnecting the carriages without extinguishing the light. A battery on

* Paper read before the British Association Meeting at Manchester, September, 1887.

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the plan I have described would not occupy more space than the receiver which is usually employed with the oil gas system, and would be far safer in every way.

The immunity from accident on our well managed railways is probably the reason that some fearful disaster has not before this attended the use of compressed gas. Railway passengers are ignorant of the dangerous nature of the illuminant, which is generally stored in steel cylinders under the carriages, although these cylinders are amply strong enough to resist the enormous pressure of the gas, but would be easily perforated in the event of a collision, with the result that the liberated gas mixing with air would either explode or in all human probability cause a dangerous fire.

If such an accident occurred in a tunnel—for instance, on the Underground Railway, where the system is generally adopted—there is the additional danger of suffocation from the escaping gas, which would occupy a very large volume of space. An accident took place quite recently on the Berlin Potsdam Railway which ought to act as a warning. An empty goods train ran into a passenger train, piercing the gas cylinder. The liberated gas, being set on fire by the goods engine, flew about in all directions, setting fire to everything in the carriage, in which there were three persons, who, before they could escape, were burnt to cinders. It is stated in the official account that the only remnant of the male passenger was "the buttons on his waistcoat." The gas receiver was a long sheet iron drum placed transversely under a second-class carriage.

It is needless to say that with electric light no such accident could happen, and as the employment of the compressed gas appears to offer the chance of either "cremation or suffocation," it would be far better for the railway companies to improve their existing oil lamp system until they can see their way to universally adopt the electric light.

THE RADIAL DISTRIBUTION OF VARIABLE CURRENTS IN THICK WIRES.

The question of the radial or sectional distribution of variable—and more especially of alternating—currents in conductors of large size is one upon which it will generally be confessed that very little light has dawned as yet upon the average electrician. It is usually, and vaguely, understood that—apart altogether from impedance—there exists a phenomenon by reason of which a given conductor when traversed by an alternating current of given mean square value presents a higher resistance, or causes a greater dissipation of energy, than when traversed by a continuous current of corresponding strength. It is, as a rule, still more vaguely held that this effect is due to a kind of tangential tendency, by reason of which the current density is greater in the exterior than in the interior layers of the conducting wire. The fundamental treatment of the subject is, of course, dealt with by Clerk-Maxwell *(cela va sans dire)*; the question has also been experimentally as well as mathematically investigated by Lord Rayleigh (see *The Electrician*, Vol. XVIII., p. 170, *et seq.*). But hitherto no very tangible conception of the nature of this phenomenon has been placed within the reach of the non-mathematical reader.

We are indebted to a paper read before the Austrian Academy by Prof. Stefan for a simple and intelligible exposition of the kind of action which takes place. Prof. Stefan conveys his explanation by the aid of analogy. Imagine, he says (in effect), a cylinder or cylindrical wire heated throughout to a uniform temperature; let it suddenly be brought into a chamber where the temperature is higher. What will take place? Obviously the outer layers of the cylinder will first rise in temperature and gradually convey heat to the successive interior layers.

Precisely the same order of phenomena occurs if an E.M.F. is suddenly set up between the two ends of the wire or cylinder. The current during the so-called variable state passes first through the outer layers alone, and gradually (using this word in a relative sense) penetrates the inner layers. When the external E.M.F. is suddenly removed, and during the gradual cessation of current due to the self-induction of the conductor, the action resembles, on the contrary, the cooling of a uniformly heated wire on passing into a colder medium—that is to say, the current ceases first, or rather *most quickly*, in the outer layers. Now, imagine that the wire is rapidly transferred to and fro between a hotter and a colder medium. It is quite easy to see not only that waves of heat will pass radially to and fro, but moreover that its condition at any moment depends very largely upon the *rapidity* of the rate of transference. When the rate of motion is sufficiently slow, the waves of heat passing any given point in the radius of the wire follow exactly with the periodic changes of position. The *amplitudes* of these variations have values which decrease from the surface inwards. When the rate of change is increased the amplitudes of the waves get shorter and shorter, and at an infinite velocity the wire would acquire an equable temperature throughout.

The electrical analogue is obvious from what has been already said, the rate of transfer corresponding to the inverse of the periodic time of an alternating current, the heat *conducting* power of the material corresponds to the electric *resistance*. But there is also the inductance of the wire, which plays a part opposed to that of the electric resistance, and which scarcely seems to have any distinct analogy in the heat system.

Prof. Stefan gives some numerical illustrations which are valuable to fix ideas, though many more will be found in the paper of Lord Rayleigh already referred to. With an *iron* wire of 4 mm. diameter, and a periodic time of one 250th sec., the amplitude of the waves of current density is about twenty-five times as great upon the surface as at the axis of the wire. For double the number of vibrations per second the external amplitude becomes only six times as great. The difference of the phases is one-third the duration of the vibration in the first case and one-half in the second. The latter statement implies that the external current is at a given moment actually in the reverse direction to the internal current. For non-magnetic wires the difference is not nearly so marked, and it decreases also as the specific resistance increases. For a copper wire of 4mm. diameter with periodic time of one 500th sec. the difference between the current density at the surface and in the centre is only 14 per cent. If, however, the copper wire be increased to 20mm. diameter then we should get the same difference as in the particular iron wire above quoted.

It is obvious that the result of this non-homogenous distribution of the current is to increase the rate of dissipation of energy, which is of course proportionate in each transverse section to the square of the current in that section. In the case of the iron wire referred to above augmentation of resistance is 48 per cent. at the lower rate of alternation and 100 per cent. at the higher. The resultant effect upon the self-induction is, however, to diminish the value of the coefficient. From this follows the apparent paradox that although the effective resistance is increased by the non-homogenous distribution of current, yet, under the same E.M.F., the current may for the same reason be greater. The effect in decreasing the resultant self-induction coefficient is more marked as the periodic time is lessened, until at length the decrease of impedance from this cause may have a most important influence in increasing the current.

ON THE ELECTROLYSIS OF ALCOHOLIC AND ETHERIEL SOLUTIONS OF METALLIC SALTS.*

BY G. GORE, LL.D., F.R.S.

As very few experiments in the above subject have been published I beg leave to record the following:—The current employed in each case was from six pairs of zinc and platinum plates, excited by dilute sulphuric acid, and the electrodes were, unless otherwise stated, 1·0 × 1·0 centimetre, and about three or four millimetres apart. In each experiment, also, the salt employed was dissolved in 5·0 cubic centimetres of spirits of wine of ·838 specific gravity, and when ethereal solutions were used, the volume of solvent was the same. The electrolysis was continued about 20 or 30 minutes in each case.

Alcoholic Solutions.

Experiment 1.—A solution of ·5 gramme of ferric chloride. With an iron anode, a copper cathode, and a strength of current = ·006 ampere, a very small amount of hard black deposit was formed upon the cathode in half an hour, and it evolved gas when wetted with dilute sulphuric acid. The anode was clean and corroded.

Experiment 2.—With a solution of ·5 gramme of chloride of manganese, a magnesium anode to facilitate conduction, and a copper cathode, the conduction was somewhat free, and the strength of current was = ·015 ampere. Gas alone was set free at the cathode, and a soft coating of magnesia formed upon the anode.

Experiment 3.—The spirit of wine at 6deg. C. was saturated with hydrochlorate of alumina. With a large anode of aluminium, a cathode of copper ·5 × ·5 cm., and a current of ·007 ampere, gas was evolved at the cathode, and colourless saline crystals were found there, but no deposit of metal.

Experiment 4.—A saturated solution of crystalline chloride of cobalt. With a platinum anode 2·0 × 1·0 cm., and a platinum

* From the *Proceedings* of the Birmingham Philosophical Society.

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cathode 1·0 × 5 cm., and a current of ·007 ampere, the cathode become covered with strongly magnetic crystalline plates of metallic cobalt. The anode was unaffected.

Experiment 5.—A saturated solution of nearly anhydrous chloride of nickel. With a nickel anode, and a platinum cathode 1·0 × 5 cm., and a current of ·01 ampere a trace of metallic nickel, much gas, and a small amount of green solid matter was formed at the cathode.

Experiment 6.—A solution of one gramme of crystals of ordinary stannous chloride. The solution conducted fairly well. With a tin anode, a copper cathode, and a current of ·013 ampere, metallic tin was deposited as a mass of crystals. No gas was set free, and the anode remained clean.

Experiment 7.—A solution of half a gramme of dry solid chloride of chromium, at 6deg. C. With a magnesium wire as an anode to aid conduction, a platinum cathode 1·0 × ·5 cm., and a current of ·01 ampere, at both electrodes gas was evolved freely, and a soft green coating formed; beneath that coating upon the cathode was a film of black solid substance, which evolved gas by contact with dilute hydrochloric acid.

Experiment 8.—A solution of half a gramme of nitrate of uranium. With a platinum anode 2·0 × 1·0 cm, and a platinum cathode 1·0 × ·5 cm., the conduction was moderate, and the strength of current = ·004 ampere. Gas was evolved freely at the cathode, but none at the anode; and a deposit of soft yellow solid substance but no metal formed upon the cathode.

Experiment 9.—A saturated solution of anhydrous chloride of zinc. With a zinc anode 2·0 × 1·0 cm., and a copper cathode 1·0 × 1·0 cm., the resistance was high, and the strength of current = ·007 ampere. No gas was evolved; no coating appeared upon the anode; but a small amount of metallic zinc in the form of a grey powder was deposited upon the cathode.

Experiment 10.—A saturated solution of anhydrous chloride of cadmium. With a cadmium anode 2·0 × 1·0cm., and a copper cathode 1·0 × 1·0 cm., the resistance was large, and the strength of current = ·007 ampere. No gas was evolved; no coating occurred upon the anode; but a deposit of crystals of metallic cadmium formed upon the cathode, and stretched across to the anode.

Experiment 11.—A solution of half a gramme of anhydrous cupric chloride. The strength of current was = ·01 ampere. With copper electrodes, the anode became coated with mixed chlorides of copper, and the cathode acquired a small amount of a dark-coloured deposit of metallic copper.

Experiment 12.—A solution of fused terchloride of antimony. With an anode of that metal, and a cathode of copper 1·0 × ·4 cm., the resistance was large, and the strength of the current = ·004 ampere. No gas was set free. Upon the cathode was first deposited bright antimony, and then loose crystals of that metal.

Experiments 13 and 14.—A solution of arsenic acid would scarcely conduct any current. With a saturated solution of potassic cyanide, and platinum electrodes, the resistance was large; gas was evolved freely from the cathode only, and no deposit was formed upon either electrode.

Ethereal Solutions.

The solvent employed was ordinary methylated ether. The solutions were at 8deg. C., and the other conditions as before.

Experiment 15.—A solution of ferric chloride. With an iron anode, a platinum cathode, and a current of ·008 ampere, no gas was evolved, nor any deposit of metal formed. The anode remained clean, but a soft coating of yellow and black substance formed upon the cathode.

Experiment 16.—With a solution of mercuric chloride and electrodes of platinum the strength of current was = ·003 ampere. No free mercury, but a coating, apparently of mercurous chloride, appeared upon the cathode. The anode remained clean.

Experiment 17.—With a solution of nitrate of uranium and electrodes of platinum, the current was = ·002 ampere, and gas was set free at the cathode only. No metal was deposited, but a thin whitish film formed upon each electrode, and reduced the current to ·001 ampere.

Experiment 18.—With a solution of anhydrous cupric chloride, a copper anode, and platinum cathode, the resistance was very high, and no visible metal was deposited during a quarter of an hour.

Experiments 19 and 20.—A solution of chloride of cobalt was almost an insulator; and one of mercurous chloride, with platinum electrodes, did not conduct at all.

Remarks.—These results, when compared with those usually obtained with aqueous solutions of the same salts, show that alcholic and ethereal solutions are much less suitable than the ordinary ones for the purposes of electro-deposition. The least unsuitable one of the present series was the alcholic solution of chloride of cobalt.

SOUTH KENSINGTON.

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT.

(Continued from page 323.)

Second Stage or Advanced Examination.

Instructions.

Read the General Instructions at the head of the Elementary paper.

You are not permitted to attempt more than *eight* questions.

You may only select *two* in Magnetism, *three* in Frictional Electricity, and *three* in Voltaic Electricity.

The value attached to each question is the same.

Magnetism.

21. What effect (if any) is produced (1) on the weight, (2) on the position of the centre of gravity, of a piece of steel by magnetising it? Give reasons for your answer.

Answer. The magnetisation produces no effect either upon the weight or upon the position of the centre of gravity. Both centre of gravity and weight are defined with reference only to the attraction between the earth and the piece of steel, and they are therefore by their definition independent of magnetic forces. Again, the magnetisation does not produce any effect that might be confounded with the effect of an alteration either of the weight or of the position of the centre of gravity, since the magnetic forces on the two poles are equal and opposite, forming a couple. Finally we might, if we pleased, weigh the steel before and after magnetisation, and we should find no difference between the two weighings, provided we took proper precautions to prevent any attraction between the magnetised steel and any part of the balance, as if any such effect took place the result obtained would, of course, not be the true weight of the magnetised steel; and with regard to the dip produced by magnetisation, if that were due to a change in the position of the centre of gravity, it is clear that the amount of dip would be the same in all azimuths, which, as we know, is not the case.

22. Two long magnets are placed vertically with their north poles (A and B) at the same level as the north pole (C) of a compass needle, one being magnetic east and the other magnetic west of C. If the compass is not deflected when the distance AC is twice BC, and if all the magnets are so long that the effects of their south poles may be neglected, show what are the relative strengths of the poles A and B.

Answer.—If A and B be the positions of the north poles of the two magnets, and C that of the north pole of the compass needle, and if M_A and M_B be the strengths of the poles A and B respectively: then, since the force between two magnetic poles is directly pro-

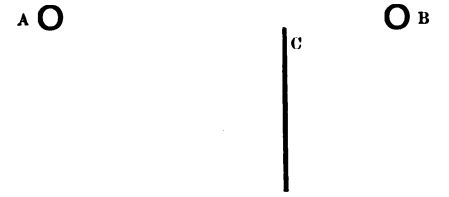

Fig. 19.

portional to the product of their strengths, and inversely proportional to the square of the distance between them, if M_C be the strength of the pole C of the compass needle, we must have, in order that there may be no deflection,

$$\frac{M_A \cdot M_C}{A C^2} = \frac{M_B \cdot M_C}{B C^2},$$

or

$$\frac{M_A}{A C^2} = \frac{M_B}{B C^2},$$

or

$$\frac{M_A}{M_B} = \frac{A C^2}{B C^2} = \frac{4}{1}.$$

So that the strength of the pole A is four times that of the pole B.

23. A compass needle is suspended at the centre of a circle drawn on a horizontal table. A magnet is moved round the compass so that its centre always lies on this circle, and that its length always points magnetic east and west. How and why will the position of the compass needle change as the magnet is carried round it?

Answer.—In the diagrams 20-21 N, E, S, W represent the four cardinal points of the compass, N S is the magnet which is moved round the circle, and *n s* is the compass needle.

For the sake of simplicity we will suppose the compass needle to be small relatively to the radius of the circle, and if the magnet

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N S be moderately strong, we may practically neglect the earth's directive force.

When the centre of the magnet N S is magnetic north of the centre of the compass needle, as in Fig. 20, the needle will set itself parallel to N S with its poles reversed, as shown. The effect of the earth's force would clearly be to cause its north pole to point slightly to the north of east.

As the magnet moves round towards E, or in the direction of the hands of a watch, its north pole N will always be nearer to the needle than its south pole, and will therefore act more strongly on the needle, which will clearly turn in the same direction, until when the centre of the magnet N S is magnetic east of the centre of the needle, as shown in Fig. 21, the needle will have assumed a direction exactly opposite to its original direction. The effect of the earth's directive force would clearly be to make it assume this position a little before the centre of the magnet N S reached the point E.

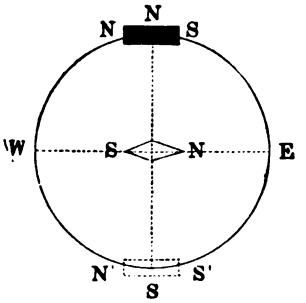

FIG. 20.*

As the magnet moves from E to S, the north pole is still nearer to the compass needle than the south pole, and the compass needle will continue to turn in the same direction until, when the centre of the magnet is magnetic south, as shown by the dotted lines N' S', Fig. 20, the needle will have returned to its original position, having made one complete revolution. The effect of the earth's magnetism will be that the centre of the magnet will have to move a little beyond the point S before the compass needle assumes this position.

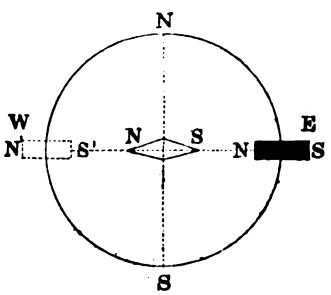

FIG. 21.*

As the magnet continues to move through W to its original position, the south pole will now be nearer to the compass needle, and the needle will continue to move in the same direction as before, pointing east and west, as shown by the dotted lines N' S', Fig. 21, when the centre of the magnet is magnetic west of the centre of the needle ; and when the magnet has returned to its original position, the compass needle will have made two complete revolutions in the directions of the hands of a watch.

24. Two magnets, A and B, are in turn suspended horizontally by a vertical wire so as to hang in the magnetic meridian. To deflect the magnet A through 45 deg. the upper end of the wire has to be turned once round. To deflect B through the same angle it has to be turned round one and a-half times. Compare the moments of the two magnets.

The moments of torsion required to produce the same deflection of 45deg. with each of the two magnets must be proportional to the moments of the magnets. But the moments of torsion are proportional to the angles through which the thread is twisted, viz., 360 – 45 and 540 – 45 respectively.

Thus we have—

$$\frac{\text{Moment of A}}{\text{Moment of B}} = \frac{360-45}{540-45} = \frac{315}{495} = \frac{7}{11}.$$

* In these diagrams the letters indicating the poles of the central magnets should be *s n*, *n s* respectively, instead of S N, N S. The error is due to the engraver.—ED. *E.*

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The accounts of this company, subject to audit, show a profit sufficient to enable the directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total of 6 per cent. for the year ended 30th June, 1887, and also the payment of a bonus of 2s. per share, both free of income-tax, which together will amount to £32,500, being a distribution in the aggregate of 7 per cent. for the past year, leaving a balance of £26,932, of which amount £25,000 has been placed to the reserve fund, increasing that fund to £112,700, and £1,932 carried forward. The above dividend and bonus will be payable on 3rd November. The traffic receipts for the week ended October 7th amounted to £3,966.

CABLE COMMUNICATION.—The Eastern Telegraph Company notifies that the Island of Formosa, in China, is connected by a cable with Foochow. Telegrams for Tamsui, Keelung, and Taipehfoo, in Formosa, are accepted at the rate of 8s. 4d. per word.

ELECTRO-METAL EXTRACTING, REFINING, AND PLATING COMPANY (LIMITED).—It is announced that this company has agreed to sell its works and business to a new company to be registered with a capital of £150,000 in £1 shares, capable of extending the operations in London, as well as by the erection of five other works in the large manufacturing centres. The shareholders of the company have all agreed to accept fully-paid shares in the Extended Electro-Metal Extracting, Refining, and Plating Company (Limited), and in many cases to largely increase their holding. The old company will be liquidated.

GLOBE TELEGRAPH AND TRUST COMPANY.—The directors, at the Board meeting of this company held on the 11th inst., declared the payment of an interim dividend on and after the 21st inst. of three shillings per share on the preference shares, less income-tax, and of sixpence per share on the ordinary shares, income-tax having already been deducted for the quarter ending the 18th October, 1887. The transfer books are to be closed from the 14th to the 21st inst., both days inclusive.

REUTER'S TELEGRAM COMPANY (LIMITED).—The directors of this company have resolved to declare an interim dividend at the rate of 5 per cent. per annum for the half-year ended 30th June last. The same dividend was distributed a year ago.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 7th October, 1887, were £3,249, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 12.		BUSINESS DONE WEEK ENDING OCT. 12. Highest.	Lowest.
Anglo-American	37,	38	37⅞	37
Do. Preferred	60½,	61½	61½	60½
Do. Deferred	14½,	14¾	15	14½
Brazilian Submarine	11½,	11½	11⅝	11½
Cuba	11¾,	12¼	12¼	11¾
Do. Preference	18,	19	—	—
Direct Spanish	2⅝,	3¼	2 13 16	—
Do. Preference	8½,	9½	—	—
Direct United States Cable	9⅛,	9⅜	9⅜	9
Eastern Telegraph	11½,	11⅝	11½	11
Do. 6 per Cent. Preference	14½,	14¾	14⅝	14½
Do. 5 per Cent. Debentures, 1899	106,	109	107	—
Eastern Extension	11½,	11¾	11¾	11⅝
German Union	10½,	11	—	—
Globe Telegraph and Trust	5⅝,	5¾	5 9-16	5⅝
Do. Preference	13½,	13½	13 7-16	13½
Great Northern	13½,	14	13¾	13⅝
Indo-European	36,	38	33	37½
Reuter's	8,	8½	8½	—
Submarine	170,	180	177½	176
West India and Panama	⅝,	¾	⅝	—
Do. 1st Preference	9½,	9¾	9½	9⅜
Western Brazilian	7⅛,	7¼	7 13-16	7⅛
Western Union 7 per Cent. 1st Mortgage	120,	125	—	—
Do. 6 per Cent. Sterling Bonds	101,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	—	—
Oriental	5-16	7-16	—	—
United Telephone	11½,	12	12 1-16	11⅛
United River Plate	4¾,	5¼	—	—

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¼,	2¾	2⅝	—
Do. (fully paid)	3,	4	—	—
Swan	1½,	1¾	1 9-16	—
Maxim Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	37,	38	38	37½
India Rubber, Gutta Percha, and Telegraph Works	21,	22	21⅝	21⅛

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NOTES.

MILE END.—At a recent meeting of the Mile End Board of Guardians notice was given by Dr. Reilly that at the next meeting he would move that the Board take into consideration the desirability of lighting the infirmary by electric light.

SHIP LIGHTING.—The report of the Royal Mail Steam Packet Company states that the directors have decided to fit the following vessels with electric light:—The "Don," "Medway," "Neva," "Nile," and "Tagus." Seven vessels belonging to the company are already supplied.

LIVERPOOL.—We are very glad to learn that the protracted negotiations between the Liverpool Corporation and the Liverpool Electric Supply Company have at length been brought to a favourable termination, and we may shortly hope to hear something of interest from that quarter.

NOTTINGHAM.—Mr. J. Blackburn, of Nottingham, informs us of the acceptance of his tender for the erection of various telephone lines for the Board of Guardians at Stoke-on-Trent; and also for fitting the new Fleming Memorial Hospital at Newcastle-on-Tyne with his improved lightning conductors.

A BREAKDOWN.—We regret to report the fact that, owing to the breakdown of an engine at the Grosvenor Gallery installation, a large number of the lamps supplied by the Sir Coutts Lindsay Company were unlit on the evening of the 18th inst. This was the more unfortunate as it happened on the opening night of Terry's new theatre, which is to be lit from the Grosvenor Gallery.

RINGING CHURCH BELLS BY ELECTRICITY.—Among the gifts to be offered to the Pope on his birthday is a contrivance by a French engineer, named Arragon, for ringing large church bells by electricity. A similar arrangement is, we believe, at present at work in a London church, the apparatus having been designed and erected by some of the students at the Finsbury Technical College.

THE ELECTRO-HARMONIC SOCIETY.—We have pleasure in calling attention to the commencement of the second season of the Electro-Harmonic Society. The first smoking concert of this society will be held at St. James's Hall on Friday, 28th October. The programme for this concert is of an unusually attractive and varied character. We trust that the present season will prove as unqualified a success as the last.

MESSRS. DE LA RUE AND CO. will publish shortly the second volume of "A Treatise on Electricity and Magnetism (Methods of Measurement and Applications)," by E. Mascart, Professor in the Collège de France, and Director of the Central Meteorological Bureau, and J. Joubert, Professor of the Collège Rollin. The work is translated by Dr. E. Atkinson, Professor of Experimental Science in the Staff College.

RYDE, ISLE OF WIGHT.—At the meeting of the Ryde Town Council last week, the Surveyor reported the result of inquiries he had made in a number of large towns where the electric light has been in use, with the view to its adoption in the borough. He moved that the matter be referred back to the Public Works Committee, and no further steps be taken, on account of the extra cost involved. The motion was adopted.

ELECTRIC WELDING IN GERMANY.—A financial association, says the *Elect. Tech. Zeit.*, has taken up the electrical welding patents for Germany of Von Bernardos and Olszewsky, of St. Petersburg. Arrangements are being made in Berlin for erecting the plant necessary to demonstrate its application to industrial purposes. It will be remembered that this method consists in using a carbon pencil to form an arc with the metal to be welded.

IRELAND.—We regret to notice a second outrage on the telegraph wires in a disturbed district of Ireland. In order to prevent information of Mr. O'Brien's midnight meeting last Saturday night—or rather Sunday morning—reaching the reserve forces of police at the neighbouring towns, the wires were cut in several places. More than this, portions of the wires were carried away so that their repair was rendered the more difficult.

A BIG SCHEME.—One of the subjects discussed at the recent meeting of the French Association for the Advancement of Science was the projected canal between Bordeaux and Narbonne. This scheme has been heard of from time to time for twenty years or more. The length of the canal, which will no doubt some day be cut, would be 330 miles, and it is proposed to light it throughout by electricity. Here is an excellent chance for the long-distance systems.

ELECTRIC LIGHTING OF DUBLIN.—On Monday last, at a meeting of the Municipal Council—the Lord Mayor presiding—the debate was resumed on the report of a Committee of the Whole House, with reference to the sufficiency of water-power at Island Bridge for electric lighting, and recommending that the Council should apply to the Board of Works for a license to use electricity for the lighting of the thoroughfares. A protracted discussion took place, and a number of amendments were proposed, but ultimately the report was adopted.

THE ELECTRIC LIGHT IN MONTE VIDEO.—It is reported that a central station is to be erected in this town for supplying the electric light. It is proposed to begin with 1,000 incandescent lamps of 12 candles, these lamps being destined to illuminate warehouses and private houses alike. It is further stated that the contract between the municipality and the gas company having expired, a proposal has been made by the new company to light the streets with incandescent lamps, of which 25 have been installed as a trial. These are said to have fully satisfied the municipality.

MOTOR DYNAMO TRANSFORMERS.—In our "Notes" last week respecting transformers we asked, What are Messrs. Paris and Scott doing? This question would have been unnecessary had we received in due course the account of Prof. Garnett's lecture in the Newcastle Exhibition on Monday, October 10th, which we now publish in another column. From this account it will be seen that Messrs. Paris and Scott have completed a transformer which works either with continuous or alternating currents, and we believe that tests of the efficiency of the machine are this week being made in the Exhibition by the jurors.

POPULAR SCIENCE LECTURES.—The London Society for the Extension of University Teaching are taking a new departure in the introduction of short courses of three lectures; the usual course having hitherto extended to ten weeks. A course of three lectures on "Electricity in the Service of Man" will be delivered by Mr. Lant Carpenter, B.A., at the Essex Hall, Essex-street, Strand, on Wednesdays, October 26th, and November 2nd and 9th. The same course will be repeated at the Shoreditch Town Hall, on Mondays, November 21st and 28th, and December 5th. The fee for admission is one penny per lecture.

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THE SUPPOSED NEW FORCE.—With reference to the account we gave last July of Mr. Crookes's investigation of the new force supposed to have been discovered by M. Thore, a correspondent, Mr. W. H. Evans, of Durban, Port Natal, requests us to notify that he obtained similar results as far back as January, 1885, by means of apparatus which he calls the entelechiascope, a photograph of which accompanies Mr. Evans's certified statement of its performances. We should advise our correspondent to put himself in communication with Mr. Crookes; and in any case to describe the instrument intelligibly, so that a rational judgment may be formed of the alleged phenomena.

CROYDON AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—The prospectus is now being circulated privately of this company, which is formed with a capital of £100,000, in £5 shares, for the purpose of supplying electric light within the borough of Croydon and the outlying districts. The company have entered into a preliminary contract with the Maxim-Weston Electric Company (Limited) for the supply of all the necessary plant. It is also stated that the assurances of financial support are such that the directors consider proceeding to allotment a foregone conclusion, and consequently do not intend to offer any shares of the first issue in the usual manner, by advertisement.

DAS TELEPHON.—Prof. Rouleaux, the well-known authority on mechanism, has addressed a remonstrance to the Imperial Postmaster-General, Dr. von Stephan, against the use of the verb "fernsprechen"—"to far-speak"—for the verb to telephone. Although the Germans consider the telephone a German invention, on the strength of the instrument called "das Telephon," by Philipp Reis, their new-born prejudice against every word of foreign origin has made them christen the telephone as the Fernsprecher, or far-speaker. But Prof. Rouleaux's own suggestion is to substitute the verb "to hift!" We suppose that a telephone will then become also a "hift," or perhaps a "hifter." And the operator a "hiftist."

MANUAL TRAINING.—An "English Merchant," writing to the *St. James's Gazette*, in answer to Mr. Samuel Smith's laudatory account of German education recently published in *The Times*, fully confirms the view maintained in our last week's leader. "English Merchant" says: "It is a great error to imagine that in Germany technical education is extended to common workmen and mechanics." In reality it is confined to "mill owners, overseers and foremen." If Mr. Smith attributes the prosperity of the German working classes to their superior education, he is quite wrong. The German workmen are well employed and earn good wages because a great number of new and important industries have sprung up in all directions during the past fifteen years.

GAS AND ELECTRIC LIGHTING IN PERTH.—The Perth Gas Commissioners, at a meeting held on Monday evening, were called upon to adopt a recommendation by the Gas Committee approving of a report by Mr. Samuel Stewart, gas engineer, Greenock, suggesting an extension of the local gas works at a probable expense of £13,000. A long discussion ensued, and it was eventually agreed to delay taking any action in the matter until the Police Commissioners should have an opportunity of considering the propriety of obtaining a report from an electrical engineer upon the introduction of the electric light into the city. This proposal was carried by thirteen votes, eight members voting in favour of the adoption of the Gas Committee's minutes. We have since learnt that it has been agreed to ask for a joint report from Prof. Ewing and Mr. Duncan Forbes. Mr. Forbes is the engineer to Messrs. Pullar and Sons, of Perth.

THE SUBMARINE TELEGRAPH COMPANY.—The following note appears in the *Bulletin des Sociétés de l'Electricité* of the 13th inst.: "The Cables between France and England.—In our issues of the 19th May and 16th June last we drew attention to the important question of the renewal of the monopoly of the submarine cables between France and England granted to the firm of James Carmichael and Co. This monopoly, conceded in 1851, expires on the 12th January, 1889. For some weeks past active steps have been taken to obtain its prolongation. The question has even been raised in the English Parliament, and the Government has expressed itself very categorically against any kind of postponement. We learn now that the French Government is on the point of granting to the Submarine Telegraph Company the renewal for fifteen years of its monopoly, which has been refused to it in England. We hope that this news is premature, and that the Government will not take a decision so injurious to the interests of telegraphy without obtaining all desirable information, and especially without asking the opinion of the Chambers of Commerce."

RUMOURS.—We hear that there is some prospect of a central station for the distribution of energy being started in a certain quarter of the metropolis.—We hear also that a primary battery will shortly make its public appearance which possesses this highly remarkable property: A single cell has an E.M.F. of, say, E volts, but when two or more cells are joined in series the E.M.F. of *each* cell becomes n E volts, where n has a value lying somewhere between 20 and 30. Consequently, with two cells a total difference of potential of 60 to 80 volts is obtained. We are getting on.—We referred some few weeks ago to a statement in one of our American contemporaries to the effect that an electric motor of American design was about to be placed upon the English market and pushed with American energy and determination. We have now every reason to believe that this rumour is perfectly well founded. The name of the American firm concerned is in our possession, and, while we have every reason to believe that their motor is a good and practicable machine, we are not aware that it possesses any marked superiority to several other motors built on this side of the Atlantic.

THE PRINCE'S-STREET SCHOOL OF ELECTRICAL ENGINEERING.—We learn that at a recent examination conducted by Mr. H. R. Kempe, of the G.P.O., the following students obtained the Vellum Certificate:—(*a*) in Electric Lighting: G. E. Hartmans, with 80 per cent. of the marks; William Green, 78 per cent.; H. R. Braid, 78 per cent.; (*b*) in Telegraphy and Telephony (these students had previously passed in Electric Lighting): G. E. Hartmans, 96 per cent.; W. J. Walters, 96 per cent.; J. R. Cotton, 90 per cent.; H. O. Halford, 90 per cent.; P. J. Pringle, 88 per cent. The course of instruction during the first few months has been lately reorganised by the managers, Messrs. William Lant Carpenter and Léon Drugman, with the view of giving greater prominence than heretofore to the mechanical side of the training. The elements of theoretical and practical mechanics are now systematically taught, as well as the principles of machine drawing. More time is likewise devoted to the short course on Chemistry. Greater facilities are also given to the advanced classes for Lathe and Workshop practice under competent supervision.

THE ELECTRO-DEPOSITION OF IRON.—Prof. W. C. Roberts-Austen, F.R.S., has been making some experiments on the

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electro-deposition of iron, a process which in Russia is used on a large scale for printing paper money. The bath used is a solution of ferrous sulphate and magnesium sulphate in equivalent proportion, of specific gravity 1·155. The solution must be so far neutralised by the addition of magnesium carbonate that blue litmus paper scarcely shows any acid reaction. A wrought iron anode, about the same size as the object to receive the deposit, must be employed, and the best interval between the poles is found to be four centimetres. Mr. Roberts-Austen finds that the current best suited for an iron medallion had a strength of only 0·089 ampere. The adherence of the iron to the copper on which it was deposited was reduced by coating the latter with a film of metal; but Mr. Roberts-Austen is trying a thin layer of silver iodide on the copper moulds. The deposited metal is very pure, and its magnetic capacity does not appear to be high. The dies for the Jubilee coins were made by this process of electro-deposition. The designs, modelled in plaster, were reproduced in *intaglio* by the electrolytic deposit of copper, and on the copper moulds so prepared iron was deposited. It is of hard and excellent quality, and dies of all sorts for coins have been produced by the reducing machine from such deposits.

THE APPLICATION OF ELECTRICITY TO FARMING.—The following note appeared this week in the *Pall Mall Gazette*:—"Among possible applications of electricity to domestic uses there is one which does not seem to have yet attracted the attention of scientific instrument makers. That is an electric lamp for farmers. At present the husbandman in the country employs either the familiar horn lantern invented by King Alfred and a tallow dip, or the more modern glass lantern, burning benzoline or petroleum. The former gives a wretchedly dim light, while the latter is difficult to light and extinguish, and is, moreover, very unsafe to carry about in linhays filled with straw. An electric lamp would not only give a bright light, but would be absolutely safe. The difficulty is to get a battery of sufficient electromotive force, that shall at the same time be constant and require little or no attention. A dynamo, of course, is out of the question. So, equally, of course, is a storage battery, for it could never be recharged in a country village. If an efficient illuminator could be produced for about seven or eight shillings, it would undoubtedly command an extensive sale." Although we should not be inclined to take so enthusiastic a view as that of the *Pall Mall*, there is no doubt a certain scope for a good portable lamp in this direction, especially when it is desired to carry on thrashing operations after dark. With loose straw about it is, of course, exceedingly risky to thrash with a naked light. Singularly enough this matter has already received attention in southern Russia, where the Stepanoff primary battery is to some extent employed during the thrashing season. The only chance the Russian wheat grower has to dispose of his crop on favourable terms is to get it on the market at the earliest possible moment, before the American and the Indian freights arrive, so that thrashing is often carried on night and day. Some further information on the subject may be found in our issue of Nov. 12, 1886.

LEAMINGTON.—The first public trial of the electric light at Leamington took place on Saturday evening. When the contract is complete, the plant will comprise three horizontal compound engines of 200 horse-power each, by Messrs. Robey and Co., of Lincoln. The double crank shafts of these engines are of steel, and machined out of the solid, having counter-weights attached to each crank-web, to balance the reciprocating parts. The main bearings are three in number, and are cast in one piece with the massive bed plate of each engine (as are the tubular guides also), to diminish the chances of anything working loose. The cross-heads are fitted with cast iron slippers, and the excentric straps are of the same material. Lubrication has been most carefully attended to in all parts of the engine. The power is communicated to the six dynamos through a line of intermediate shafting, which stretches across the whole width of the engine room. Each engine is fitted with a heavy grooved fly-wheel, 10ft. diameter, driving a similarly grooved pulley on the countershaft by means of nine 1¼in. cotton ropes. Six grooved pulleys of 6ft. diameter upon the shafting drive the dynamos in the same manner. The shafting itself is in two lengths connected by friction clutches, and the driving pulleys are also provided with friction clutches. Two of the engines are already in place, and the third is rapidly approaching completion in the workshops of Messrs. Robey and Co. The dynamos are of the Chamberlain and Hookham type, but we shall postpone a description of the electrical arrangements for a separate report. The boilers are 19ft. 3in. in length, 5ft. 1in. in diameter, and have a heating surface of 740 square feet. They are made of Siemens-Martin steel, and have a working pressure of 140lb. The machinery and entire plant are in duplicate. The proprietors of the works are the Midland Electric Light and Power Company, who have arranged with the Corporation to light the Parade and Bath-street, and to supply the light to the Town Hall and the Pump Rooms. A large number of the principal tradespeople have given orders for private supplies of the light.

ELECTRIC STREET LIGHTING IN BERLIN.—The Berlin correspondent of *Industries* reports that at a recent meeting of the Berlin Town Council it was resolved by 91 votes to 3 to light Unter den Linden with 104 arc lamps. Dr. Hagan has been commissioned to report upon the proposed illumination, and is entirely in favour of it. He is of opinion that the installation will be the most perfect example of street lighting anywhere in the world, the amount of light proposed being largely in excess of the usual requirements. Interruption of the light need not be apprehended, he says, as is abundantly proved by the small installation in the Friedrichsstrasse, which has already been at work for three years. After midnight the number of lamps burning will be reduced to 46; and even with this reduced number there will be plenty of light to render the traffic safe. The installation will be erected by the Berlin Electric Works, who have also acquired the central station in the Friedrich-strasse belonging to the Edison Company, and which is very favourably situated, being near the middle of Unter den Linden. In this station there are four Edison 500-light dynamos, each driven by an Armington Sims engine. To this plant will now be added some arc light machines. The present network of cables will be joined to the network belonging to the Berlin Electric Works. The Leipzigerstrasse has already for some years been lighted electrically, there being 36 lamps burning with 11 amperes. The Berlin Electric Works have officially informed the Town Council that they are extending their network within their original district, and that they are ready to go outside their district, provided the Town Council will give them a new concession, in which case they would undertake to erect a new central station in the Spandauerstrasse, to be ready by October, 1889, for the supply of 6,000 lamps of 16 candle power. The capacity of this station would, within three years after the opening, be increased yearly by 6,000 lamps; so as to reach in 1892 a total capacity of 24,000 lamps. The company also offer to build, by October 1st, 1890, another central station in Dorotheenstadt, having a capacity of 6,000 lamps to begin

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with, and increasing this to 12,000 lamps within two years. These offers have been favourably received by the Town Council.

SCIENTIFIC LECTURES AT THE NEWCASTLE EXHIBITION.—On Monday, October 10th, Prof. Garnett, the chairman of the Lecture Committee and of the Electric Lighting Committee, lectured in the theatre of the Newcastle Exhibition upon some electric appliances. The lecturer showed various experiments illustrating the production of electric currents by different methods, and the storing of electrical energy. A small model brougham, the lamps of which were supplied with electric light from Schanchieff's sulphate of mercury battery, and a number of surgical electric lamps surrounded by water-jackets, and constructed by Messrs. Mawson and Swan, were exhibited. But the chief novelties were the electric welder constructed by Mr. Manville, of the United Electrical Engineering Company, after the plan of Prof. Elihu Thomson, and the transformer of Messrs. Paris and Scott. The electrical welder was furnished with an alternating current from an alternating Gramme machine employed by Messrs. Woodhouse and Rawson in running the Jablochkoff lamps in the engine room, the current passing through 900 yards of No. 12 copper wire. The instrument was manipulated by Mr. Stewart, who has charge of Messrs. Woodhouse and Rawson's installation in the Exhibition. As, in addition to the cables employed in lighting the theatre, there was only one set of leads from the engine room available for experimental purposes, some delay occurred in getting the leads transferred from the alternating machine to the continuous current machine in the engine room in order to exhibit Messrs. Paris and Scott's transformer. During the interval Mr. Stewart suggested trying the alternating current upon the transformer. The armature, of course, remained at rest, but the lamps on the secondary circuit glowed apparently to precisely the same degree of brightness as when a continuous current of the same E.M.F. was employed. In the latter case, of course, the armature rotated, and the electromotive force in the lamps increased until the maximum speed of rotation was reached. The machine appeared to be self-regulating to a highly satisfactory degree, though no exact tests could be made in the course of the lecture; but when half the lamps were switched off the remainder appeared to be practically unaffected. Messrs. Paris and Scott may be congratulated on the behaviour of their transformer on the first occasion of its trial in public.

THE WATER PRIMARY BATTERY COMPANY.—The report of the meeting of the above company, which will be found in another column, contains much information of a most curious character, and will afford plenty of food for contemplation by every intelligent and well-informed mind. The report should be read especially by those who desire to obtain an insight into the latest development of electrical science—and finance. Take, for instance, the remarkable revelation made by M. D'Humy, in reply to Colonel Innes, a gentleman who, premising that he did not profe s to know anything about electricity himself, stated that "a thorough electrician had declared to him that the plates could never last." M. D'Humy, according to the report, said in explanation that "in the water battery there were two kinds of plates—one iron, the other carbon. *The objection referred to the carbon plate.* Undoubtedly if there were any silica in the carbon plate it would perish, but in his invention there was no silica, but pure carbon, and therefore it was indestructible. (Hear, hear.)" In the absence of any "thorough electrician" (beside himself), it was of course easy for M. D'Humy to put his own interpretation upon the objection. But the time has certainly come when M. D'Humy should pay some attention to the difficulties experienced by those who *have* some acquaintance with the subject, and we once more invite M. D'Humy to explain from what source the energy supplied by his battery is obtained. The battery, as our readers are already aware, consists of iron and carbon plates immersed in dilute nitric acid; the carbon takes the form of a deep and narrow box, and the strong acid is poured into this receptacle and filters through into the outer cell which contains the iron. Any ordinary chemist or electrician would conclude that the energy is derived from the oxidation of the iron plate by the dilute acid. But this, as we understand it, is denied by M. D'Humy. We have ourselves seen iron plates which M. D'Humy assured us had been in use for many weeks without perceptible loss. This was twelve months ago or more, and M. D'Humy was not at that time prepared to come before the public, and had not fully made up his mind as to the source from which the cell derived its energy. But if (as he now seems to have convinced himself) neither the iron nor the carbon undergoes any change, we are compelled, in the interests of pure science as much as in those of the investing public, respectfully to demand that we shall no longer be kept in the dark upon this vital point. Does M. D'Humy's battery derive energy from the decomposition of water? or is there some catalytic action between the carbon plate and the nitric acid? or is the E.M.F. entirely due to the endosmose of the acid through the carbon? or is it in some obscure way a thermo-electric effect? a Peltier, or a Thomson effect? is it connected with the Hall phenomenon? has it any relation to Dr. Schüster's recent discovery? or is it an extreme case of metamorphic polarisation of the equivalent atomic charge by incipient molecular disintegration? (Personally, we incline somewhat to the latter view); or, if none of these, then what, in plain words, is M. D'Humy's own explanation of the result which he has obtained? We feel sure that M. D'Humy would not so confidently have promised the investors a return of 100 per cent. within twelve months had he not thoroughly thrashed out the subject to his own satisfaction. And we feel the more emboldened to put these plain questions from the honest and straightforward way in which the chairman of the company announced that "if anyone had the slighest doubt of the validity and value of the machine, and its ability to effect what M. D'Humy said it could, let him put any question to that gentleman, and he would no doubt answer to his own satisfaction and to the satisfaction of them all." We have put our questions and await a reply.

STATE TELEPHONES IN AUSTRIA.—A correspondent in Vienna sends us the following:—The Austrian Government has decided to inaugurate a system of State telephone exchanges, and the official publication of this intention, with detailed conditions of price, &c., was published on the 11th inst. in the official *Gazette*. The document is a curious one, and has connected the State monopoly of telegraphs with telephones, making the telephone seem part of the State telegraph service. The preamble states that the Government have decided to connect mills, factories, business houses, stores, &c., with the telegraph offices whenever requested to do so by them, for the purpose of telephonic transmission of telegrams; further, for the purpose of receiving and sending "phonograms," a new idea, briefly meaning that messages may be dictated per telephone to the post or telegraph office to be sent on from there by letter or post-card per post to any part of the world, or, on the other hand, letters or post-cards received at the post office marked for telephonic transmission

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can be dictated to the subscriber from the office before being sent on in the usual way. The above, of course, only refers to such towns where no concessions have been granted to private companies, as in those towns where concessions exist the Government does not intend erecting State telephones, as in all of them the exchanges are already connected up with the telegraph offices, and have undertaken the transmission of telegrams to their subscribers, the charges of these existing exchanges being very low already, perhaps the lowest in Europe. The Telephone Company of Austria have now a large number of subscribers in the various towns, and have deserved well of the country by the energetic way in which they have pushed their business in spite of many and varied difficulties. The Government tariff is also guided by the same consideration as the preamble. There is an initiatory installation charge of 50 florins for 500 metres distance from post or telegraph office and 10 florins additional for each 100 metres; then 30 florins annually as a charge for keeping the line and apparatus in order. For telephonic transmission of telegrams a charge of five kreuzers (one penny) for each telegram so sent or received, plus half kreuzer for each word apart from the usual charge for the telegram. For "phonograms" a charge of five kreuzers for each message plus half kreuzer each word, to which, of course, the usual postage is added, and also a small charge for the letter paper and envelope, and, lastly, in the words of the document published, "if a number of such telephone lines are connected up with the telegraph office the subscribers can be connected with each other," and for this a further charge of 20 florins annually is to be made. So the idea of the telegraph is adhered to logically throughout the document, and the real object, viz., the erection of State telephone exchanges in those towns where no private exchanges exist seems really to be only a secondary consideration; it comes in almost as an afterthought. The draughtsman of the document has carried out the ruling idea very cleverly indeed, and if he was also the inventor of the "phonograms" he has not only found a very good word for messages dictated by telephone, but if this idea succeeds, he has initiated quite a new convenience for the public, especially as the private exchanges are sure to adopt these with the permission of the Government. It will be seen that the charge is really 50 florins per annum plus a special installation charge of 50 florins plus 10 florins for every 100 metres beyond the original 500. The charges of the Telephone Company vary according to the size of the towns, the larger being, of course, dearer, but they vary from 60 florins to outside 90 florins a year, out of which 10 florins a year have to be paid to the State, a very large royalty indeed, and one which gives the State an excellent revenue. So the charges do not vary much from those proposed for the State Exchanges.

INDUCTION TELEGRAPHY TO AND FROM BODIES IN MOTION. At a recent meeting of the New York Electrical Club Mr. Charles A. Cheever read a paper upon the above subject, which is now attracting considerable attention in America, and which, as our readers are aware, has received practical application upon several important railroads. In tracing the history of the invention Mr. Cheever referred to the paper read by Mr. Willoughby Smith before the Society of Telegraph-Engineers on Nov. 8th, 1883, in which the following passage occurs:—"Now it has occurred to me that volta induction might be employed with advantage in various ways for signalling purposes. For example, one or more wire spirals could be fixed between the rails at any convenient distance from the signaling station, as that, when necessary, intermittent currents could be sent through the spirals; and another spiral could be fixed beneath the engine or guard's van and connected to one or more telephones placed near those in charge of the train. Then, as the train passed over the fixed spiral, the sound given out by the transmitter would be loudly reproduced by the telephone, and indicate by its character the signal intended." At the time when this paper was being written Mr. Phelps, whose system is now a practical success, had just commenced to experiment upon the identical lines independently laid down by Mr. Willoughby Smith. It appears, however, that the earliest record of the idea is contained in a United States patent, issued in 1881, to another W. Smith (Mr. Wiley Smith). In this specification the plan of using a "buzzer" does not occur, and the patentee relied upon the direct inductive effect of Morse key makes-and-breaks between an adjacent wire and a closed circuit (including a telephone receiver) carried by the train. It is obvious that the method of Phelps is capable of giving far better results in practice, but yet Mr. Cheevers has found that with a receiver having 700 to 1,000 ohms resistance it is possible to read a message when the terminals of the instrument are merely attached to the opposite ends of the roof of a single car. The distance of the inducing circuit and the battery power used is not given. For the Phelps system as at present in use a battery of twelve chromic acid cells is employed. Each cell is 2 inches wide and 4 inches deep. This battery is closed on an induction coil having a primary coil of about 3 ohms and a secondary coil of about 500 ohms, and provided with an ordinary vibrating make-and-break. Messages are sent with a Morse key placed in the secondary circuit. The receiving telephone has a resistance of about 1,000 ohms. The line wire is stretched on poles 16ft. high at an average distance of 8ft. from the rails. The train circuit is made up of wires carried through the train from car to car and fixed just under the roof. In concluding the paper Mr. Cheever said: "I have not taken your time with the discussion as to the various uses and advantages which may be obtained by the induction telegraphy, nor as to the numerous improvements which I know to be under experiment and outline for the future. Arrangements are already perfected whereby duplexing, or even quadruplexing, may be accomplished. Experiment has been made for transmitting articulate speech to and from moving trains, and whether this can be reduced to a practical success remains to be seen. As far as we have gone, we have met with encouraging results with the line wire situated 8ft. distant from the moving car. There seems to be no reason why, with the proper adaptation of the elements employed, communication between ships could not be arrived at. Telegraph line wires may in the future be laid through our rivers and sounds, and with suitable coils upon the boats moving up and down the streams communication may be had with them. Edison, Gilliland and Phelps have all experimented in the direction of ship telegraphy, and the results give great encouragement of ultimate practical success. To conclude while the results are now all that can be desired for telegraphic communication to and from railroad trains, there is still a vast field of other uses for induction telegraphy yet open for experiments to make them practical and useful." In the discussion which followed, Lieut. Toppan called attention to a singular phenomenon in connection with the working of static induction, stating that in crossing the iron bridge which spans the Mississippi river between Minneapolis and St. Paul, and which is several hundred feet long, with the wires a number of feet below the bridge, there was no apparent falling off in the inductive effect, and the operators were able to work as well at that point as anywhere else on that branch of the Chicago, Milwaukee and St. Paul Railway.

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THE PRACTICE OF DYNAMO DESIGN.

BY GUY C. FRICKER.

(Continued from page 435.)

Thus far, dynamos of the most usual types have been considered, and their design reduced to as exact a process as the present knowledge of the subject admits. The chief uncertainty has clearly been that relating to the magnetic leakage from pole to pole, or rather from all points on the magnetic circuit differing from each other in magnetic potential. We have not been able to gauge this quantity with any great degree of accuracy, and have been perforce content to make a fairly near approximation to it in the application of a very simple rule.

It is also clear that this magnetic leakage is the great defect in modern dynamos, making it necessary to provide field-magnets of enormous cross section compared with the actual number of lines which pass from them through the armature. This objection has been partially met by the so-called iron-clad dynamo, in which the magnetising coils are surrounded by the iron in which the induction is required.

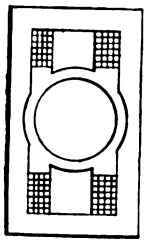

FIG. 17.

A good illustration of this arrangement was given by Kapp in a series of articles on dynamo design and construction in *The Electrician*, Vol. XIV., page 391, and for the benefit of those who may be unable to refer to this number the figure is here reproduced. Viewing the exciting coil in section it is evident that by enclosing the copper by iron in the way shown, the magnetic "whirl" or sheath is conducted without permitting any lines to stray into the surrounding space. There are this design, however, certain lines which pass across the air spaces from pole to pole without entering the armature, and are thus useless for the production of E.M.F. in the circuit.

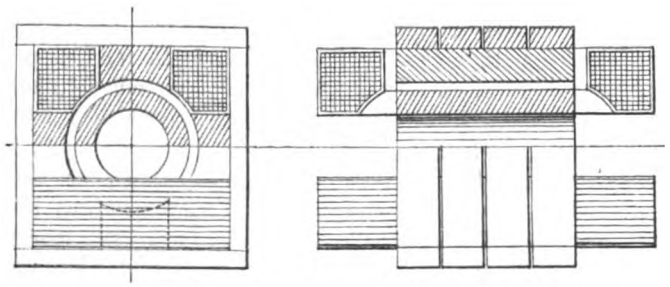

FIG. 18.

In a modified form of this machine designed by the present author this waste field is minimised and the geometry of the circuit so arranged as to secure a very large activity for the cubic space occupied. On a reference to the illustration of this machine in Fig. 18 it will be seen that the section of the exciting coil is almost entirely surrounded by the iron in which the induction is required, the only gaps being those necessary for the introduction of the armature winding. In spite of the apparent merits of the above arrangement the results in regard both to weight and efficiency are by no means encouraging. To give point to this we will calculate the dimensions of a 10-unit machine of this type, and compare it with those previously dealt with.

Starting with the following values for the fixed quantities viz. :—

$p = \frac{1}{3}$	$M = 20$
$q = 3$	$P = 4$
$\beta = \cdot05$	$\gamma = \cdot7$
$\rho = \cdot9$	$\mu = \cdot6$

we get $R = 3\cdot6 \times 1\cdot154 = 4\cdot16$; say, $4\frac{1}{8}$in.

$N = 243$

$A = \cdot00494$

$\mu\beta R = \cdot126$

whence, making two layers, the section of wire is $\cdot0786 \times 063$ giving $\mu = \cdot61$.

By adjusting N to 240 turns we should get a 60-part commutator with 4 turns to each section. The total number of lines passing through the armature is

$$Z = \frac{117 \times 10^6}{240 \times 1000} = 488.$$

Without any elaboration on the point we may assume that, including the waste lines, which in this design are very few, the total induction will not be greater than 550—that is, 225 lines through the section $pq\gamma R^2$. The section of the field-magnets will thus be $AB = \frac{225}{18 \times \cdot8} = 15\cdot6$ square inches.

The cores may be conveniently arranged in four pieces, each 3in. wide, placed side by side, with a short air gap between contiguous bars; the thickness of these bars would be $\frac{15\cdot6}{12} = 1\cdot3$in., or say $1\frac{3}{8}$in. The magnetic resistances may be taken as follows :—

$$R_A = \frac{4}{11\cdot9} = \cdot335$$

$$K R_A = 2\cdot45 \times \cdot335 = \cdot825,$$

and from the former rules $\delta = \cdot3$in. In this design the angular extent of the pole-pieces may be increased to $\frac{\pi}{3}$, because they cover the outer portion of the ring only. We then get

$$R_a = \frac{1440 \times \cdot6}{53\cdot7} = 16\cdot1;$$

also in this case

$$R_F = \frac{L}{AB} = \frac{19\cdot5}{16\cdot5} = 1\cdot18 \; ; \; K_2 R_F = 2\cdot45 \times 1\cdot18 = 2\cdot9.$$

Thus $p_1 = 16\cdot925 \times 488 = 8300$; $p_2 = 2\cdot9 \times 550 = 1600$,

and $P = 9900$.

This exciting power must be exerted by each of the bobbins, the parallel magnetic circuit excited by one bobbin only having been considered above.

The procedure for determining the size of these exciting coils must be different to that previously adopted, because we no longer have the same conditions of ventilation. In the former designs the current density in the field coils has been about 1,300 amperes per square inch for this size of machine; it will, therefore, be probably quite safe to assume a density of 1,000 amperes for the coils in question. The variation in density with the linear dimensions will follow the same law as before. Retaining the former average current of 7 amperes, the section of wire is ·007 square inch, which corresponds to a circular wire of ·0942in. diameter, and gives

$$\mu_1 = \cdot885 \times \frac{\cdot0942}{\cdot0942 + \cdot02} = \cdot73$$

The total number of turns are $\frac{9900}{7} = 1414$, and the area occupied by the section of these wires is

$$\frac{1414 \times \cdot007}{\mu_1^2} = 18\cdot6 \text{ square inches.}$$

The sectional area provided by the proportions shown in the figure is about $23\frac{1}{2}$ square inches, which includes the necessary margin for the magnet case.

On analysis we find the weights of the various parts to be as follows :—

Armature core	60lbs.
Magnet bars	280 ,,
Pole pieces	190 ,,
Armature winding	11 ,,
Field-magnet winding	315 ,,

The total weights are thus :—

Iron	530lbs.
Copper	326 ,,

The resistance of the armature will be ·0533 ohm and the loss in watts 533. The loss in the magnets is 610 watts, the electrical efficiency is thus only $89\frac{1}{2}$ per cent.

Before concluding the subject of continuous current dynamos, an interesting point on the magnetic resistance of the air gap δ may well be mentioned. For a considerable time

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Mr. Kapp had been puzzled by the disparity of his experimental figure of specific air resistance, 1,440, and the true figure of 1,860, more especially because experience has shown that 1,440 is quite high enough to fulfil the conditions of the actual case. At the British Association Meeting at Manchester he had some conversation on this matter with Prof. Ewing, who pointed out that although as compared with *iron* the resistances of air and other non-magnetic substances are identical, yet, compared among themselves, discrepancies of even 100 per cent. might exist; in fact he, Prof. Ewing, had found copper to be much more permeable to magnetism than air, and since a great part of the gap δ is composed of copper a solution of the mystery may thus be found.

There are many other forms of the continuous current dynamo, to nearly all of which a treatment closely analogous to that given in the foregoing papers may be applied. No good purpose would be served, however, by multiplying examples; this part of the subject of dynamo design will therefore be closed with the typical forms which have here been considered.

(To be continued.)

THE NORTH METROPOLITAN TRAMWAYS COMPANY AND THE ELIESON ELECTRIC LOCOMOTIVE.

The extended series of trials of the Elieson and other systems of electric traction which are taking place upon the lines of the North Metropolitan Tramway Company cannot fail to have a marked influence upon the progress of electric traction in this country, and our readers will doubtless be glad to have an authentic account of the results so far obtained, and especially of the impression which has been made upon the Directors of the Tramway Company.

On the 6th of June the Elieson locomotive commenced running upon the line between Stratford and Manor Park, a distance of four miles and a-half, and since the early part of August, when certain initial difficulties were finally overcome, the service has been conducted with perfect regularity. The very fact that we have all along regarded these experiments with an earnest desire for their success has led us to refrain from chronicling in our columns the petty difficulties and mishaps which are necessarily incident to the early days of such an undertaking. The failure of the connection of a battery cell may stop a car, and may suggest the desirability of altering the pattern of the binding screw, but it is not a criterion of the value of the system, and such breaks-down should, in our opinion, no more be made the subject of public comment in a technical journal than if a similar mishap occurred in a laboratory experiment. The propriety of such reticence is the more obvious when, as in the present case, the experiments are conducted at private charges and not with the money of a public company. Mishaps were not infrequent when the Elieson Electric Locomotive Company first undertook the Manor Park service; on one occasion the whole of the engines were withdrawn for several weeks. This misfortune arose from the continued snapping of the armature wires at the point where they are connected to the commutator. The Elieson system does not, however, rely upon any special type of motor, and the machines now furnished by Messrs. Paterson and Cooper do their duty extremely well. During the last ten weeks the service has been conducted with just the same degree of regularity as that of the horse cars. Our authority for this statement is not derived from any mere off-hand estimate, but from a personal inspection of the daily records, which have been most carefully compiled by the officers of the Tramway Company, and which have very kindly been placed at our service by Mr. Adamson, the general manager of the North Metropolitan Tramway Company. In these records entries of a minute description are made relating to the daily performance of each engine and car. Some two months ago we went over the line in company with Mr. Elieson; the plant had at that time just been brought into good working trim, and the impression which we received after a careful inspection of the whole of the arragements was one very favourable to the system as a practicable mode of traction. This impression is fully borne out by the experience since gained and by the testimony of the Tramways Company. "There is no doubt in our minds," said Mr. Adamson, "that the Elieson engines are fully capable of doing the work which we require." So far so good. But this does not touch what is, after all, the question of supreme importance, and the only question with which the Tramway Company professes to be concerned. It is obvious that no amount of technical excellence in the design of the gearing or in the arrangements for charging the cells, no degree of smoothness and regularity in the working, will permit us to overlook the all-important question of finance, and until the working cost, rate of depreciation, and capital charges have been fully worked out, the commercial value of the system remains an unknown quantity.

Unfortunately it is yet too early to arrive at definite conclusions on these points. This is admitted on both sides. The question of depreciation in particular is one upon which a much more extended experience is required. As to working cost we have this much to go on:—The first offer made by the Elieson Company was based upon a rate of 3½d. per car mile. The actual working expenses for horse traction upon the North Metropolitan Lines are a trifle over 5d. per car mile. The Tramway Company voluntarily offered to make the rate 4½d. instead of 3½d., stating that their object was not to effect an immediate saving, but to obtain a thorough test of the practicability of the system. The Elieson Company inform us that they have not been able as yet to determine the exact cost per car mile which has been incurred, but, as will presently be seen, they are quite willing to accept a more extensive contract at the same price.

Now as to capital account. On the North Metropolitan lines every car is worked by 10 horses, with one spare animal. The average price paid is about £36 to £37. The life of a tram horse is known to be a short if not a merry one, and the rate of depreciation is high; in fact, at the present time horse-flesh and secondary cells probably run a close race in the matter of depreciation, with the odds somewhat against the horse. There is, moreover, reason to believe that the breed of horses is not improving so rapidly as that of lead plates.

Under the system of separate locomotives, with cells permanently fixed in position, it is necessary to have two engines for every car. The cost of these engines is about £542, made up as follows:—Car, £95; 80 accumulators, £240; motors and gearing, £207. This represents an initial expenditure of about £1,100 per car, as against only about £400 for horses, so that to put the two systems on an equal footing in this respect the depreciation must be at only one-third the rate in the former case.

On another matter relating to capital charges it is unfortunate that at present something in the nature of a deadlock exists between the two companies. The facts are these:—The Elieson Company has hitherto been permitted to use part of the premises of the Tramway Company at Stratford as a charging station and engine house. These premises are already fully occupied by the seven engines at present at work. Now the Tramway Company are willing that the Elieson Company should undertake the whole of the traffic on the Manor Park line; but this would require about twenty cars. The Elieson Company have therefore proposed at their own expense to equip a new station at the Manor Park end of the line, and to build new self-contained cars for the additional service. They ask, however, that the Tramway Company should purchase or rent the land and erect the necessary sheds. This the Tramway Company are not inclined to do. They are perfectly willing to contract with the Elieson Company for the performance of the service, but do not see their way to incur any initial outlay. And so the matter stands.

Meanwhile we may add that preparations are now being made for working the Barking line solely by electric traction, the arrangements having been placed in the hands of the Electric Traction Syndicate, who will employ motors of the Immisch type. We are informed that in this case the initial outlay does not exceed that for horse traction. Self-contained cars will be employed, which are being constructed by the North Metropolitan Tramway Company.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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NOTICE.

We beg to notify that all correspondence and contributions intended for this Journal should be in future addressed to THE ELECTRICIAN, 1, Salisbury-court, Fleet-street, E.C., instead of to Mr. C. H. W. Biggs, whose connection with it has ceased. We deem it right to add that no other change whatever has occurred or is contemplated in the proprietorship or management of this Journal.

ANSWER TO CORRESPONDENT.

MR. C. G. MALLESON, MELBOURNE.—*Dr. Cornelius Herz is the editor of "La Lumière Electrique," and no doubt you would be able to obtain from the office of that journal the information which you seek.*

MORE ABOUT THE PROPOSED ASSOCIATION.

It was not our intention to recur again so soon to the subject of the proposed ASSOCIATION OF ELECTRICAL ENGINEERS, especially as the scheme is rapidly gaining favour throughout the profession, and is experiencing no serious opposition from any quarter whatever. But some of the letters which reach us, and some of the comments which have appeared in the technical and trade journals supporting our proposition, betray a certain divergence of opinion as to what the objects of such an Association ought to be; or rather a misapprehension of the particular objects we ourselves had in view when recommending its formation. Indeed, in the few places where we observe a languid interest in the project, or hesitation in giving it a hearty co-operation, we detect some misgiving that it may either intentionally or unavoidably conflict with an existing institution or society with which the several professions concerned are already identified. Again, there is an impression that existing corporations, if more life were put into them, or their mode of procedure were altered to meet the wants of our clients, might obviate the necessity for any new departure. On both these points, before matters proceed any further, we think it expedient to offer a few words of explanation, which may tend to remove every objection or hesitation of the kind referred to. We have intended to be perfectly candid all along, and if any misunderstanding has arisen it must be due either to our own want of clearness or to some of our readers suspecting us of designs that we have never contemplated.

First, then, as to the societies with which such an Association as we propose could in any circumstances conceivably clash. The British Association has been mentioned, likewise the Institute of Civil Engineers, the name of the Dynamicables has also been whispered, but, above all, the claims of the Society of Telegraph-Engineers and Electricians have been heard the loudest. Now, the simplest answer in respect of the three largest and most important of these associations is that our scheme more closely resembles the fourth and least formidable of their number—namely, the Dynamicables. Some of our readers may know very little of those gatherings which, under social guise, assemble and meet for purposes which are essentially business-like. Their designation is sufficiently descriptive of their professions; and they have thought and probably found it their interest to unite for concerted action in matters relating to their several callings. They are said to be somewhat convivial; but no objection will be taken to their doings on that score; and, indeed, by way of a beginning, we are inclined to think that something convivial would be desirable for the inauguration of a scheme which, having all the business objects of the Dynamicables, would embrace a much wider circle and vastly augment their powers of usefulness. Nobody has complained that the motives and aims of these electrical and amicable engineers are antagonistic to the well-being of any other society whatsoever; and we distinctly claim for the proposed ASSOCIATION OF ELECTRICAL ENGINEERS that neither would it be open to any such charge. What we desire, in short, is a business or trade combination with which science and scientific societies, except indirectly, have nothing whatever to do.

Such a combination, including members of every electrical manufacture and industry, can never dissociate itself from the scientific sources from which their livelihood springs, any more than the commerce of the world can dispense with the teachings of political economy. But just as ADAM SMITH'S place is not exactly on 'Change, so the place of the scientific electrician is not among practical electrical engineers, though they profit by his researches elsewhere, in the same way that merchants profit by the science of the political economist. And here we may add that we rather deprecate any disparagement of the work and proceedings of this or that society by way of advocating the formation of a new one. We are persuaded that neither the British Association nor any association of that kind could meet the requirements of the case, even if they tried their utmost; and as regards the special and distinct societies already in full operation they have their own work to do, and so far as we know do it very well indeed. Only on one point would we venture to offer criticism in this relation, because it has a direct bearing upon the scheme we are discussing. It will be admitted, we believe, that the proceedings of the Society of Telegraph-Engineers occasionally have been tinctured by what it is no disparagement to call the "commercial" instinct. Consequent on the unprecedented growth of electrical industry during the past eight or ten years the intrusion of a trading element is perfectly natural; and all we have to say about it is that so long as there is no other

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and more appropriate outlet every learned society will be liable to this reproach. We believe that there would be a distinct gain to the dignity and usefulness of the Society of Telegraph-Engineers if the commercial spirit which sometimes pervades its discussions were kept outside. Possibly the fact that there exists no such provision at present may account for so many important electrical papers finding their way to societies which are not in any special sense identified with electrical research.

After expressing ourselves thus frankly and in full accordance with the great majority of the opinions which have been expressed to us by those chiefly interested, it will, we trust, be perfectly clear that the objects of the proposed ASSOCIATION OF ELECTRICAL ENGINEERS are of a purely business character. To protect their own interests, to promote their own industries, and to discuss the best means of securing these ends, would be the foremost objects of its members—objects which will be none the less easily attainable for being openly avowed. Some of these industries are hampered by legislative restriction, and others by parochial obstruction, to such an extent that nothing short of a compact and powerful organisation will effectually secure free and fair play to their natural and legitimate development. We have not before mentioned the telegraph cable proprietors and manufacturers; but it is not improbable they may see it to their advantage to join in such a combination for the common good. Many dangers threaten these industries, not the least of which is the confiscatory spirit which pervades the political atmosphere in these days, and which is the inspiring motive of the prohibitory conditions imposed upon Electric Lighting enterprise and the establishment of Electric Locomotion. But with or without the co-operation of any particular branch of electrical business, there are a sufficient number directly affected at the present moment to justify them in the formation of an ASSOCIATION OF ELECTRICAL ENGINEERS; and their interests are of sufficient magnitude to induce them, we are persuaded, to combine in some such manner as that we have indicated.

THE LATE PROF. GUSTAV KIRCHOFF.

It is with profound regret that we have to announce the death, on the 17th inst., at the age of sixty-three, of Prof. Gustav Kirchoff, of the University of Berlin. Kirchoff's name is a household word to physicists and chemists alike, from his discovery of the cause of the Frauenhofer lines, or dark lines of the solar spectrum, which formed the foundation of the method of spectrum analysis which was given to the scientific world shortly afterwards in the joint researches of Kirchoff and Bunsen.

He was the author of numerous papers in the scientific journals on various branches of physics, in which he showed himself a skilled experimentalist, as well as a mathematician of the highest order; but, with the exception of his spectroscopic work, his investigations were mostly cast in too mathematical a form to become generally accessible in their original shape.

His investigation of the distribution of electric currents in a system of linear conductors, of which the Wheatstone bridge is a simple example, has become generally known through the text-books, and the original paper offers no special difficulty. His paper "On the Determination of the Constants on which the Strength of Induced Electrical Currents Depends," published in *Poggendorff's Annalen* in 1849, is worthy of special note, as having for the first time furnished a means of determining the resistance of a wire in absolute measure, as was pointed out by Maxwell. His paper "On the Theory of the Flow of Electricity in Submarine and Underground Telegraph Wires" is one of great interest to the practical telegraphist; but it is likewise one which will make very considerable demands on his mathematical acquirements. His investigations of the flow of electricity in wires and superficial conductors and of magnetic induction in iron are electrical classics, and these and other papers, among which we may mention "The Theory of Condensers" and "The Measurement of Electric Conductivity," are both valuable and suggestive, and should not be passed over by electrical students who possess the privilege conferred by a competent mathematical knowledge. A collection of Kirchoff's papers up to date was published at Leipsic in 1882, and we trust that his later investigations may shortly be republished in a similar form.

Kirchoff was an able teacher as well as a great investigator, and his loss will be keenly felt by the students of the Berlin University. Those who have not had the privilege of studying under the great physicist may form an idea of his clear and lucid style of imparting instruction from his "Lectures on Mathematical Physics," published at Leipsic in 1876. On the first appearance of this book the late Prof. Clifford was so struck with it that he proposed translating it for the benefit of English students, and indeed he actually began the work, but was prevented from completing it by the illness which terminated in his death.

G. W. DE T.

A NEW ARC LIGHT DYNAMO WITH AUTOMATIC REGULATION.

We had recently an opportunity of seeing at Messrs. Statter and Co.'s works in West Drayton a new dynamo intended for series arc lighting, and provided with automatic regulation for constant current. The field-magnet of this machine is of the single horse-shoe type, with the yoke in the bed-plate and the poles above. The armature is a Gramme ring 12in. diameter by 10in. long, the core consisting of segmental soft iron plates put together so as to form a continuous annulus according to Joel's patent. The amount of iron both in the armature and field is about the same as would be employed for a glow-lamp machine of equal output, and in this respect the design has the advantage of low magnetic resistance, a strong field, and consequently a fairly high electrical efficiency. It is well known that to obtain a steady light the characteristic of the machine should in the neighbourhood of the working current have a slight downward slope, and this condition can be fulfilled (and in many of the early arc light machines has been fulfilled) by making the magnets of somewhat scant dimensions, and providing an abnormal exciting power, so that the strength of the field should attain its maximum—that is, the magnets become saturated long before the working current is reached. This will give the required downward slope to the characteristic, but at a considerable sacrifice in efficiency and output. In the machine under notice steadiness of the light is obtained in a different way, and the magnets need not be over-saturated, a point of importance both on account of efficiency and first cost.

The regulating mechanism is as follows:—To the support of the bearing on the commutator side is attached a vertical solenoid inserted with the external circuit. The attraction on the core of this solenoid is counterbalanced by an adjustable spring, and the core itself is connected by a rod with a double spring pawl pivoted in a fulcrum which receives a slight horizontal reciprocating motion from a vibrating lever, the lower end of which engages with a pin set excentrically in the end of the armature spindle. Below the pawls are two ratchet wheels, with the teeth pointing in opposite directions. Both these wheels are mounted upon the same spindle, which runs parallel to the armature spindle and controls the position of the brushholder by means of a pinion and segment. As long as the current is of the normal strength both pawls are kept clear of the ratchet wheels, and the position of the brushes remains unaltered, notwithstanding the horizontal oscillations of the pawls. But if the current falls or rises, and thus alters the position of the core in the solenoid, either one

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or the other of the pawls is caused to come into contact with its respective ratchet wheel, and the brushes are thereby shifted until the current returns to the normal strength, when the pawl is again thrown out of gear.

When the brushes stand on the neutral diameter the electromotive force is a maximum, and it decreases as the brushes are shifted towards the centre of the pole-pieces, being zero when a position at right angles to the neutral diameter is reached. Thus any electromotive force corresponding to the external resistance (number of arc lamps in circuit) can be produced, but this method has the disadvantage of heavy sparking at the brushes unless special precautions are used. To avoid sparking it is evidently necessary to so construct the machine that the number of lines passing through the coils under commutation should be constant for all positions of the brushes, and since this number depends not only on the strength and distribution of the primary field, but also on the secondary field produced by the armature itself, the problem is by no means an easy one. Mr. Statter has attempted a solution by weakening the primary field in those places where it would otherwise be too strong. To attain this object grooves were cut out in the polar surface, so as to increase locally the magnetic resistance of the air space and obtain an even distribution of the lines which are due to the combined primary and secondary field, through an angle of nearly 90 degrees. The exact shape of the grooves was determined experimentally by testing the difference of potential existing between adjacent commutation plates at different angular distances from the neutral diameter. It is evident that these grooved pole-pieces are equivalent to smooth and continuous pole-pieces, the length of which measured parallel to the spindle varies in different points of the circumference; but grooving has been adopted as easier for experiment. In this connection it is interesting to refer to a somewhat similar device adopted throughout for the same purpose by Messrs. Mather and Platt in the large "Manchester" dynamos at the Manchester Exhibition. In these machines the polar surface, instead of being concentric with the surface of the armature, is struck to a greater radius, so as to make the air-space greater at the corners of the pole-pieces than in the middle. This design seems intended to produce an even field and avoid heating in the iron of armature and pole-pieces, but whereas here the magnetic resistance is locally increased near the neutral line, Mr. Statter increases it on the polar diameter, the difference being probably due to the fact that the Manchester machine has a double, whereas Mr. Statter's has only a single magnet. The machine weighs 17½cwt., and is intended for a maximum output of 10 amperes at 600 volts, the speed being 600 revolutions per minute. During our visit the resistance of the external circuit, which consisted of Bernstein glow lamps and iron coils, was varied from 60 ohms to zero, and the regulator appeared to be very sensitive and quick in its action.

THE PROPOSED ASSOCIATION OF ELECTRICAL ENGINEERS.

Out of the mass of correspondence which has reached us on this subject we select the following for insertion. The remainder of the correspondence may be seen at this office. We may add that so far as the London firms are concerned there remains only a very small number who have not already expressed their approval of the movement:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice with interest that the question of an Electrical Association has been again brought forward. I regret that I have not by me the correspondence now passing on the subject in some of the technical papers, but I wish to take this opportunity before another week goes by of saying that I should personally be extremely glad to see a strong Electrical Association brought into existence, and I think that the action which my firm took rather more than twelve months ago in this matter, associated as we then were with several of the leading electrical firms, is sufficient proof that any such association as the above, if started upon sufficiently broad and impersonal lines, would be sure to be strongly supported. I shall be glad to see from your columns, or from those of your contemporaries, what further action is being taken, as I think that now is a most favourable time for the matter to be pushed forward. I have expressed my opinion personally, as I believe that a large concensus of personal opinion is the first necessary step.

Trusting, therefore, that you will find room for this letter.—Yours, &c., J. F. ALBRIGHT.

Mansion House Buildings, London, E.C.,
17th October, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue you refer to a movement for the establishment of an association for the advancement of the electrical industry. One need hardly bring proofs of the need of an organisation of this kind, sufficient proof being the evidence of the number of attempts that have been made during the last five years by those interested in electrical work to form an organisation to forward their interests. These attempts have up to the present failed, chiefly, I believe, for two causes—first, that they were not universal enough, but confined chiefly to a few leading firms; secondly, that the details were not sufficiently thought out. There is no doubt in my mind that if we are to have an association with such recognised status that it can bring pressure to bear upon Parliament, and that its membership or certificate may be an honourable distinction, and not the mere matter of payment of a fee, it must be an association supported by all, carefully thought out, and with a properly formed organisation and a proper and efficient staff. As yet the whole scheme is floating in the air, and needs a definite shape. I would suggest that the matter be taken up by someone known to be unbiased, say, the representatives of the technical press, that a meeting of those interested in electricity be called at the Cannon-street Hotel, and that, after discussing the matter, a representative committee be elected to draw up a report to be published and laid before a subsequent general meeting, showing the different methods in which the scheme might be carried out, and pointing out their relative advantages and disadvantages. At this subsequent meeting the scheme might be settled upon and a permanent committee appointed, in which all degrees of those interested should be fairly represented, and a definite line of policy laid down, so that one might have an opportunity of seeing whether it is worth while joining it.

In conclusion I may give a list of points, a few of which it may be worth while for the association to take up:—

1. To bring pressure on Parliament in such matters as Lightning and Tramway Acts.
2. To remove legal restrictions and obstacles to the growth of the industry generally.
3. To aid in the opposition to vested interests where opposed to electrical work.
4. To establish public confidence, especially in the financial and commercial world.
5. As far as possible, by inspection or otherwise, to compel firms to do good work.
6. To approve of articles and methods (hall mark).
7. Maintenance of prices at a fair level.
8. To act as a registered authority for tests.
9. The conferring of certificates, both upon individuals and upon articles.
10. The comparison (wire gauges), issuing and certifying of standards.
11. The minimising of and dealing with fire and life risks.
12. Registration of applicants for employment.
13. Registration of "black sheep."
14. Protection of the trade financially.
15. Stamping out of blackmailing and similar systems.
16. Arbitration between firms and individuals.
17. To give opportunities for conferring together on the above subjects.—Yours, &c., F. L. RAWSON.

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TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: We observe with pleasure that the proposal to establish an association for the discussion and development of practical and commercial electrical engineering is likely to become an accomplished fact.

We shall be glad to support such an association, and to assist, as far as possible, in its formation.—Yours faithfully,

TASKER, SONS AND CO.

New Station-road, Sheffield, October 17, 1887.

Industries, of the 14th inst., contains the following remarks on the subject:—

PROPOSED ASSOCIATION OF ELECTRICAL ENGINEERS.—The hint thrown out a fortnight ago by our contemporary, *The Electrician*, which recommended British electric light engineers to follow the example set by their American colleagues, has been favourably received by professional men both in London and the provinces. American electricians have, with a view to further their common interests, established an electric light convention; but on this side of the Atlantic there exists at present no similar organisation, although there are two societies for the furtherance of electrical work. The one is the Society of Telegraph-Engineers and Electricians, which was originally started by telegraph men, but has of late years concerned itself to a considerable extent with the scientific aspect of heavy electrical engineering; the other is the society known as the Dynamicables, which started with the intention of combining the social, scientific, and commercial elements in the profession, but which, attempting too much, has not been very successful. The proposed association of electrical engineers would concern itself more especially with the commercial, legislative, and administrative portions of the electric light business, leaving the scientific part to be dealt with as hitherto by the Society of Telegraph-Engineers and Electricians. That some such organisation has plenty of scope must be patent to all who have of late years studied the slow growth of the electric lighting industry in this country.

The current number of the *Engineer* contains the following:—

AN ASSOCIATION OF ELECTRICAL ENGINEERS.—It has been proposed that an Association of Electrical Engineers should be formed with a view to founding a corporate body whose functions should be concerted action in all matters in which those are interested who are engaged in the manufacture of electrical engineering machinery, apparatus, and appliances, and in general with the commercial applications of electricity, and also as a means of providing for the desirable frequent meeting of all electrical engineers with the view of discussing subjects of current or particular interest, business questions, or those upon which it is desired that the opinion of the body should be taken with a view to influential action in Parliament or elsewhere. *The Electrician* has called particular attention to the subject, and already it appears that a considerable number of electrical engineers have written in support of the proposal, and of the necessity for an association which shall take the place of a business association instead of one of a scientific character. At the meetings of the Institution of Civil Engineers the trade side of matters is properly kept out as much as possible, and the society with the long name requiring a fount of type to print it, namely, the Society of Telegraph-Engineers and of Electricians, does this also to a great extent. There are other societies, such as the Iron and Steel Institute, whose discussions and proceedings deal with business questions much more; but what is required isan association which provides the means for carrying out the objects already mentioned, and of providing for frequent meetings at which men can, as at a social gathering, or in body, discuss questions set forth in a programme upon any matter which is exercising the minds of electrical machinery makers, designers, apparatus makers, or those who are engaged in installation work or provision of *matériel* for it. The matters most occupying attention, or upon which discussion may be usefully directed, can often be put before a meeting in ten minutes' speaking, and by men who cannot get the time to prepare formal papers. A properly and vigorously conducted development of the society known as the Dynamicables, but with a more business name, is what is required.

[In Mr. J. V. Money-Kent's letter, which appeared in our last issue, by a slip of the pen in the tenth line, the writer expressed the reverse of what he had intended to convey. The sentence in question should have read that the Society of Telegraph-Engineers "is *not* likely to trouble itself about commercial questions."]

ON THE LOCALISATION OF A COMPLETE FRACTURE IN A SUBMARINE CABLE BY BRIDGE MEASUREMENT TO INSTRUMENT ZERO.

BY A. E. KENNELLY.

(Concluded from page 482.)

We will now examine the accuracy of the method embodied in these equations (22) to (36). Of course, if the premises assumed in the formation of equations (16) to (21) are true, then the distance of a fracture could always be calculated with certainty in this manner. The premises require, besides accuracy of the balances and the instruments establishing them, that the resistance f of the fracture shall vary inversely as the square root of the traversing current, and also that E, e, and η shall remain constant through the three measurements.

As regards f, we know that it does not vary strictly according to the inverse square root law when the exposed surface of the conductor at the fracture is small, for reasons that appear by experiment to be connected with the mechanical insulation of the exposure by accumulating gas at different rates of evolution. Thus it unfortunately happens that when the exposed area is less than a certain limit, which may be roughly stated at half a square centimetre, the rate of variation in f descends from the inverse square root towards the inverse cube or fourth root of the traversing current. Consequently, on this ground alone, the accuracy of the method is confined to cases where the exposure has such dimensions that the gas evolved on it escapes unimpeded, and that its resistance is steady to any steady testing current from the zinc-pole of the battery.

By selecting a suitable battery we can depend upon the constancy of E within close limits, but e and η are, of course, beyond control. If e varies, then, by sufficient repetition of x, y, and z, it may be possible to eliminate the effect of this variation on the result, as e is clearly independent of c. The case is, however, different with η, which we know to be a function of c, increasing as c increases, but at a rate which we have not been able to assign. In many experiments we have found that η varies approximately as the direct fourth root of c, but the rate of variation appeared to differ not only with different exposures, but at different points in the range of current strength through the same exposure. Thus it generally appears that when c is small η increases faster than the cube root of c, but that as c increases in value the rate of increase in η diminishes until it falls below the fourth roots, and, consequently, the assumption in the generating equations (16) to (21) that η is constant involves an error in the result.

These two errors—one of f's deviation from inverse square root law and the other of η's inconstancy—unite in reducing d and D; and the question arises, what values should be assigned to n and m that the error in the result shall be a minimum?

Equations (25) to (29) show that the same sign of error in d and D introduces errors of contrary sign into the calculation, and that an error in d vitiates the result more than the same error in D. Thus an error of δ in both d and D affects the result by formula (26) with $3{\cdot}5\delta$, formula (27) with $1{\cdot}13\delta$, (28) with $1{\cdot}67\delta$, and (29) with 7δ, so that it is advisable to make m large and n small, formulæ (26) and (27) giving the best results in practice.

That the variation of η may have less influence on the

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results it is advisable to make E, the testing E.M.F., conveniently large, and not to employ very feeble currents.

We will now state one or two practical examples of the method.

Experimental case with exposure of about 2 sq. cms. of cable core conductor in circuit with resistance only. E approximately 45 volts. Zinc to line $\frac{1000}{1000}$ ($\lambda = 1$).

With 2 milliamperes to line ..... $x = 1450\omega$
" 8 " " " ..... $y = 1305\omega$ $(n = 4)$
" 18 " " " ..... $z = 1270{\cdot}7\omega$ $(m = 9)$

Here $d = 34{\cdot}3$ and $D = 179{\cdot}3$, so that by formula (26)

$$l = 1270{\cdot}7 - 4 \times 34{\cdot}3 + \frac{179\,3}{2} = 1223{\cdot}2\omega,$$

and by direct bridge measurement l was 1226ω.

When the exposure was small, however, such a degree of accuracy was seldom met with. The following, for example, was a case with a small exposure :—

With 3 milliamperes to line..... $x = 795$
" 12 " " " ..... $y = 504{\cdot}9\omega$ $(n = 4)$
" 27 " " " ..... $z = 434{\cdot}6\omega$ $(m = 9)$

Here $\lambda = 1$, $d = 70{\cdot}3$, $D = 360{\cdot}4$, and $\therefore$ $l = 333{\cdot}6\omega$. The actual value of l by direct measurement was 350ω.

The following results were obtained with a broken cable in which the fracture was recovered the same day, and the area of exposure found to be approximately 0·6 sq. cms. 225ω distant ($l = 225$). In addition to a series of readings to false zero, three sets and a series were observed to true zero as follow :—

20 Calland cells. 100/1000 Zinc to line.

With 6 milliamperes to line $\frac{x}{10} = 436\omega$.
" 24 " " " $\frac{y}{10} = 290\omega$. $n = 4$.
" 54 " " " $\frac{z}{10} = 260{\cdot}5\omega$ $m = 9$.

Here $d = 29{\cdot}5\omega$, and $D = 175{\cdot}5\omega$, and by (26) $l = 230\omega$.

SET No. 2. *Similar conditions :—*

With 5 milliamperes to line $\frac{x}{10} = 460\omega$.
" 20 " " " $\frac{y}{10} = 298\omega$. $n = 4$.
" 45 " " " $\frac{z}{10} = 264$. $m = 9$.

Here $d = 34$, and $D = 196$. $\therefore$ $l = 226$.

SET No. 3.

With 3·5 milliamperes to line $\frac{x}{10} = 539$.
" 14 " " " $\frac{y}{10} = 319{\cdot}7$ $n = 4$
" 56 " " " $\frac{z}{10} = 257{\cdot}3$ $m = 16$

Here $d = 62{\cdot}4$ and $D = 281{\cdot}7$ and by formula (28) $l = 226$.

The following series was then taken :

Milliamperes Current to Line.	Balance Reading ÷ λ.	Milliamperes Current to Line	Balance Reading ÷ λ.
50	259·7	10	347 5
45	262·8	9	359·0
40	265 7	8	374·0
35	269·8	7	393 0
30	275·5	6	419·0
25	283·0	5	457·0
20	294·5	4	540·0
15	312·0	3	589·0
		Check 50	259·9

Various combinations can be taken from this set and solved by formula (25). If selected so that m and n are small, the results will be found to have large errors in some cases, but by selecting n and m more judiciously greater accuracy will be obtained.

We have thus seen that the law of inverse square roots can be applied to the elimination of f in measurements to true as well as to false zero. The false zero method enables a complete series of observations to be taken in such a manner that pairs of readings may be selected from various points in the range, and the values of l so found serve to check the result with greater facility than a series of true zero observations can under the same conditions afford. The errors in the result, owing to any deviation of f from the law, or to the inconstancy of η, are also less in the false zero method than in the other, for algebraic reasons. On the other hand, the true zero method is not limited like its competitor to a current range of 25 milliamperes, for the reason that it measures the true value of η, which the false zero method applied to cables can never do, since by the time the electrostatic discharge on removing the testing battery has ceased, η has always fallen considerably, consequently the current through the galvanometer while the battery is removed is not the current that would be produced by the full $\pm(e \pm \eta)$ actually in the cable during the testing current's flow. Therefore, there can be little doubt that if the laws which connect the increase of η with the increase of e could be ascertained and applied, it would be possible by true zero formulæ like those detailed above to localise a large exposure fracture with great accuracy. The fact that these formulæ have already served to fairly localise such exposures both experimentally and in the practical instance mentioned, is perhaps, on a due consideration of their intricacy, a crucial test of the truth of the inverse square root laws.

In conclusion, it may be pointed out that formula (7) supplies a simple and convenient method of measuring to true zero the apparent conductor resistance of a perfect cable containing earth current E.M.F. The ordinary method of doing so is by reversing the battery, and observing x and y with opposite poles to line. The formula for solving l is then somewhat lengthy. If, however, we can by any simple means double the unreversed testing current to line either by doubling the testing E.M.F. (compensating for extra battery resistance) or by the use of ρ in the figure, we obtain by the Mance formula $l = y - d$ strictly, or if the form be preferred,

$$l = 2y - x \quad . \quad . \quad . \quad . \quad . \quad . \quad (37)$$

and the case taken from Sir Henry Mance's paper, solved above after equation (11), is coincidently an instance of this.

SUMMARY.

The method of localising a fracture described above is based on the laws of inverse squares connecting the current strength surfaces and resistances of exposures in sea water. It consists of measuring the resistance of the fracture and cable up to the fracture by bridge to true zero, with the zinc pole of the battery to line, three times in succession, with a different and definite strength of current to line each time. The best ratios of current strength so to employ are given at equations 26, 27, and 28. From the three balances thus obtained the distance of the fracture can almost be calculated mentally. As an example, taking the case of equation 26, the current strengths sent to line in the three successive measurements are as 1, 4 and 9. The balance readings—always using zinc to line—will be found practically to be in descending magnitude, the first greatest, the third least. Then the distance of the fracture from those readings would be the third added to half the difference between the first and third, reduced by four times the difference between the second and third.

It is not pretended that in every case the distance of a fracture can be exactly calculated in this way. Like the false zero method of determination based on the same laws error cannot be excluded, and each method has its own advantages and its own particular liability to error, as compared above;

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but by care these errors may, in most cases that occur practically, be so minimised that their effect on the calculated result may be neglected, and with fractures of considerable exposed area will in any case be small.

The relative superiority between the "false-zero" and "true-zero" methods must be left to general experience and opinion.

LITERATURE.

Dictionnaire d'Electricite et de Magnetisme. By E. JACQUEZ. New Edition. [Paris: C. Klincksieck.]

A revised and enlarged edition of M. Jacquez's "Dictionary of Electricity and Magnetism" has made its appearance. The new edition contains more than 400 additional terms, and the whole work has been brought fairly well up to date. So far as we have yet discovered the collection errs—if it be an error—on the side of inclusiveness rather than exclusiveness. At any rate, we have always succeeded in finding the term for which we have made search; and, on the other hand, have come across many terms which we should certainly never have made inquiry for. This remark applies particularly to phrases used in connection with telegraphy, such, for instance, as "Changement de service," "Remise de service," "Reprise de service," "Livre de remise de service," all which phrases refer simply to the transfer of duty amongst the clerks in a telegraph office. It would, however, give a very unfair idea of the actual value of this work to allow it to be supposed that it is chiefly made up of such phraseology as the above. On the contrary (as, in fact, we have already intimated), it contains a well-nigh exhaustive list of the technical terms and phrases employed both in the theoretical and applied sciences of electricity and magnetism. Each term is connected with the English and German equivalent, and a sufficient explanation or amplification is given in the French. The aim is to provide a dictionary and not an encyclopædia, but in very many cases the treatment is sufficiently full to be of some value to the student who is in search of instruction. This remark is, however, only of partial application. "Magnétisme" is, for instance, dismissed in four lines, while "Magnétisme Terrestre" occupies more than a page. The work concludes with a collection of German-French and English-French synonyms. We might suggest to the author the propriety of including in a future edition a set of tables of resistances, &c.

STANDARD LAMPS.*

BY A. VERNON HARCOURT.

At one of the meetings of this section last year a lamp, devised by the author, for producing a constant amount of light was shown and described by Mr. W. S. Rawson. The lamp now exhibited served the same purpose, but is simpler in principle, more easily adjusted, and less affected by draughts. It consists of a glass reservoir with tubulure and stopper of the form and size of a large spirit lamp, mounted on a metal stand provided with levelling screws. The wick could be turned up and down in the usual manner within a long tube attached to the body of the lamp. Around this tube is a wider tube 100 by 25 millimetres, and the two being joined together above and below by flat plates constitute the burner of the lamp. When the burner becomes warm by conduction of heat from the flame, the pentane which arises from the wick volatilises and burns at a considerable distance above the point to which the wick is turned. Thus, the size, or texture, or quality of the wick does not affect the flame. Round the burner and the lower part of the flame is another cylinder, opened at both ends, and contracted above the burner to the tube, 20 millimetres in diameter and in length. A similar tube formed the lower part of an upper opening, which was enlarged above to a diameter of 25 millimetres. The upper part of the flame was concealed by this lamina, excepting where a narrow slot, 10 by 3 millimetres, on each side showed the tip of the flame, and enabled its height to be regulated. Through the interval between the two laminas the flame shines, and the light which it gives is the same whenever the top of the flame is visible through the slot, whether towards the lower or the upper end. The two laminas were attached together by two curved metal bands sufficiently removed from the flame on either side not to affect it. The attachment of these bands to the lower lamina was adjustable, so that the opening through which the central parts of the flame were seen might be made larger or smaller. By means of small cylindrical blocks whose thickness was actually gauged, the width of the opening might be set either to that which the light emitted or one candle, or if a greater or a smaller light was desired, a candle and a half or half a candle, the width of the connecting bands was half that of the tube which surrounds the flame. When these bands were placed in a plane perpendicular to the bar of the photometer point, midway between their edges and at half the height of the flame might be taken very approximately as that from which the light radiated. The liquid with which the lamp is fed is pentane in the manner already described from American petroleum.

* Abstract of a paper read before the British Association Meeting at Manchester, September, 1887.

ON ELECTRIC STREET CARS, WITH SPECIAL REFERENCE TO METHODS OF GEARING.*

BY A. RECKENZAUN, C.E.

Scarcely nine months have passed since your esteemed president, Mr. T. C. Martin, presented a paper on "Electric Street Cars" to the American Institute of Electrical Engineers. I have read this excellent paper with interest, and I have learned a great deal from it, as also from the discussion which followed. Mr. Martin compiled some very important statistics regarding the number of horse cars in actual use in the United States, and he computed them to number 25,000, for the propulsion of which no less than 120,000 horses are requisite.

These figures filled me with wonderment and surprise, and when I read further on that over 20,000 of these noble animals are rendered useless every year with overwork in street railway service, I felt it to be the duty of every engineer, electrical or mechanical, to assist with every means in his power in the emancipation of the horse from such cruel service. The percentage of loss given in the paper referred to agrees closely with our European experience. We know that the natural life of a street car horse is reduced to about four years, although it never works more than four hours a day. It seems barbarous, therefore, to employ animals for such purposes; yet until recently no economical substitute could be found. Steam, compressed air, gas and spring motors have been tried and found inefficient. Improvements may be made in one or more of these, but at the present moment the field of enterprise is entirely open to the cable and to electricity. There are over eighty miles of cable roads in operation in the United States, more than half of which have been laid down within the last five years, and there are indications that further and rapid progress will be made with this mode of traction, particularly in hilly districts, where it is impossible to apply self-propelled cars owing to the want of cohesion between the wheels and rails when the angle of repose is approached.

On ordinary streets with gradients of not more than 5 per cent., electric traction will doubtless be more economical and far more convenient than cables, for well-known reasons. Not only is the first cost of construction far cheaper than the cable and its conduit, but the efficiency of the electric system is much greater.

It is admitted that on cable tramways some 70 or 80 per cent. of the total available power is consumed in dragging the cable itself, leaving a maximum of 30 per cent. for moving the cars, whereas with electric transmission over 50 per cent. can be utilised, as will be seen by the following figures, which I have obtained from experiments on the electrical railway at

* Paper read before the American Institute of Electrical Engineers, New York, Sept. 20th, 1887.

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Frankfort, in Germany. This line is worked by the overhead conductor system. Its total length is four and one-tenth miles, double track and grooved rails. The entire circuit of the conductor is eight and one-fourth miles long, and its electrical resistance was calculated to be 1·6 ohm.

EFFICIENCY AND WORKING COSTS.

During the experiments referred to, two cars were propelled at a speed of seven and a-half miles an hour; one of these cars had an electric motor, and the other was an ordinary car attached to the first, and the entire weight was ascertained to be 8·35 tons, including passengers. Electrical measurements were taken from the dynamo at the power station simultaneously with those on the car. The rails were in their usual dirty condition. When running on the level road the energy used on the cars was 3·87 horse-power, and on the generating dynamo 6·47, giving an efficiency of 59·82 per cent.; when travelling up a grade of 1 in 45, the motor gave 8 horse-power and the dynamo 13·5, which again corresponds to 59 per cent. of the available electric energy. These measurements do not include the losses in the dynamo and motor, but it must be remembered that only two cars were on the road, whilst the capacity of the plant at the central station was sufficient for 14 cars. With 12 cars running under the ordinary circumstances of traffic, the steam engines were indicated, and this showed a maximum of 164 horse-power, consuming two and three-fourth tons of coal per day of 15 hours, or two and one-half pounds per indicated horse-power per hour. Reduced to car miles, the weight of coal came to 7·5 pounds, which, at three dollars a ton, would cost one cent per mile run.

The Frankfort electric railway has carried over 3,000,000 passengers since its opening in April, 1884. The working expenses in the year 1886 amounted to $24,904, including the following items:—

Salaries of directors, superintendent, engineers, electricians, conductors, drivers, firemen, and labourers	$13,615
Repairs of roadway, rails, cars, machinery, and buildings	5,088
Fuel (coal and kindling wood)	3,955
Oil and waste	831
Lighting and heating of buildings, lighting of cars and streets	1,415
	$24,904

The rolling stock consisted of 14 cars, all of which were used on Sundays and holidays, but only eight cars were usually running on week days. If we take an average of 10 cars, then the entire expenses would amount to $6.82 per car per day, but not more than one-third of this, or $2.27, can be reckoned for the item of traction, which should only include wages of engineers, electricians, firemen, cost of coal, oil, and repairs to machinery.

There are about a dozen electric railways in successful operation in Europe, some more extensive than the one I have just described, some smaller; but this one in Frankfort is worked at a greater expense than any of the others I know of; it has been in continuous use for nearly three and a-half years, and I thought that by giving you detailed and exact figures of *one* line, I would serve your purpose better than by attempting to crowd a few generalities of all our electric tramways into the small compass of a short paper. You can take this as a safe standard of comparison with other systems of street car traction.

It will be observed, with justice, that the dynamos and motors of the Frankfort line, which was projected more than four years ago, do not yield as high an efficiency as more recent machines. This would leave us another margin. It is well to have a margin in all our estimates, for there is nothing that retards the progress of a novel enterprise more than exaggeration of facts, or statements which cannot be fully borne out in practice.

Some people are apt to base their calculations and estimates upon theoretical conditions. We should never assume perfection in the case of street railway tracks, but, on the contrary, we ought to adapt ourselves to the roughest of the rough in order to succeed.

TRACTIVE FORCE AND MECHANICAL RESISTANCES.

We know from experience that street rails which are exposed to dirt, grit, stones, and the like, offer a resistance of at least 20 pounds per ton with the wheels in motion. Taking the loaded car at six tons, and the speed at six miles an hour, we have to exert 1·92 horse-power at the driving wheels, neglecting friction of gearing and losses in the electric motors. On narrow grooved rails, as used in England, we allow a tractive force of from 25 to 30 pounds per ton. These high resistances are readily accounted for when it is considered that the flanges of wheels frequently take a bearing on the dirt in the grooves; at the same time the wheel tyres may roll on the suface of the rails, when a regular grinding action is produced. Furthermore, it occurs frequently that one wheel is running on its proper bearing surface, whilst the other, belonging to the same axle, has its flange touching the bottom of the groove, when by virtue of different circumferential velocities, additional friction is introduced. Sometimes the rails are a little out of gauge. All these points increase the tractive force requisite with grooved rails. Here in America you have few, if any, such rails, consequently the facilities are superior; but your rails are not so strong as those used in England and on the Continent of Europe, and the foundations are less substantial. The joints are also somewhat irregular, and these faults render the motion of a car very unsteady. A ride on some of the roads in Philadelphia reminds one of a voyage on the ocean when the sea is a little rough. Then you crowd very often 70 passengers into a car which is supposed to hold about 30. All these circumstances compel us to provide plenty of power in order that every obstacle can be overcome.

The force necessary for starting a car is of course much greater than the force required for maintaining a uniform speed, and experiments show that this initial effort amounts to three times and even four times the tractive force of the car in motion. In dry weather, on curves of 50ft. radius, the resistance to traction is doubled, and on those of 35ft. radius trebled; but when the rails are wet this resistance, due to curvature, is considerably reduced. With a short wheel base, or, better still, with small trucks or radiating axles, the motion on curved rails is very much easier.

(To be continued.)

THE LEVER DYNAMO.

This machine differs from others in that the armature has projecting teeth which revolve in grooves in the pole-pieces.

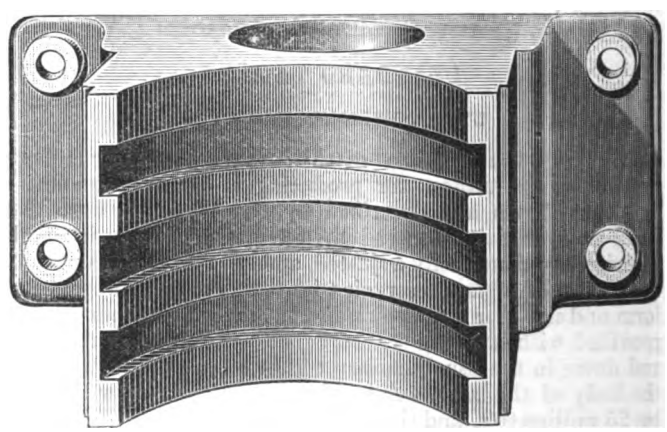

FIG. 1.—Grooved Pole-piece of Lever Dynamo.

Fig. 1 shows a grooved pole-piece and Fig. 2 the armature. By thus increasing the surface of the iron of the armature the magnetic resistance of the air space is evidently reduced. The grooves in the pole-pieces are made in the same machine which bores them out. Fig. 3 shows the dynamo complete. It is of compact construction, and occupies little floor space. The field-magnets are massive, and we are informed that there is an entire absence of sparking at the commutator with hardly any lead at the brushes. The dynamo is also said to have a high efficiency of conversion.

The first machine built in accordance with this design was tested at Messrs. Blakey and Emmott's works, Halifax, with

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the result that at a speed of 1,550 revolutions an E.M.F. of 210 volts was obtained with a current of 11 amperes. The resistance of the armature is 1·31 ohm, resistance of field-magnet coils ·84 ohm. Mr. Lever informs us that he hopes to reduce the armature resistance very much in later machines of this type.

THE LEVER ARC LAMP.

The new type of lamp illustrated in the adjoining figure has a solenoid in lieu of the electro-magnet employed in the older type. There is no glycerine required in this lamp.

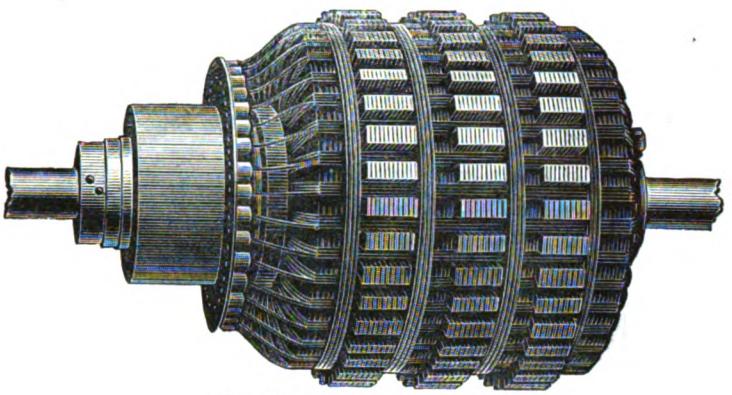


Fig. 2.—The Lever Armature.

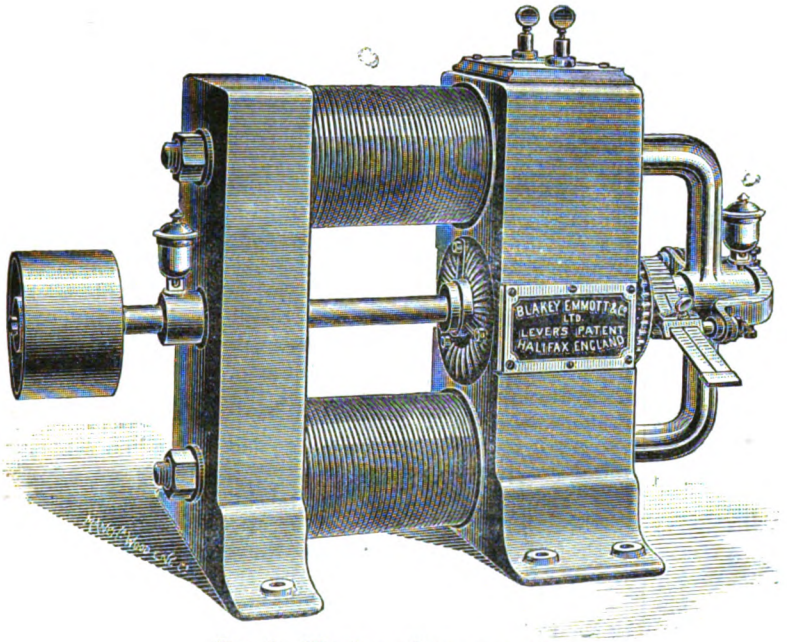
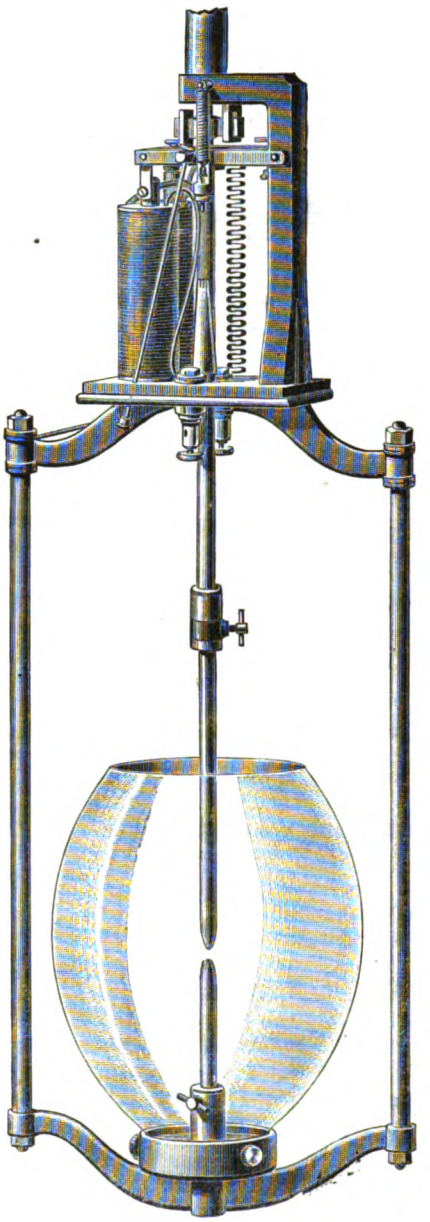


Fig. 3.—The Lever Dynamo, complete.



The Lever Arc Lamp.

The solenoid plunger fits nicely but easily in the brass spool of the solenoid, and when it is attracted there is a slight compression of the air within the spool. A brass link is connected to the plunger and lever. The lever is free to oscillate on a pin fixed in the upright arm of the top frame. A spring, adjustable by a nut on the lever, and held at the top by another pin in the frame, draws up the lever in its normal condition. The hollowed clutches held by its arms in two sleeves, one fixed to the frame and the other movable with the lever. The upper carbon holder slides freely through the clutch and through bearings in the frame, and is protected by an outer brass tube screwed on to a bush cast with the lamp frame, by means of which the lamp is suspended. The thin copper brush, shown in the illustration, transmits the current to the upper carbon holder. Mr. Lever assures us that in working it is only with the most careful attention that the feeding can be seen, so gently does the upper carbon descend, and the lamp will give a very steady light with cheap American carbons, thus reducing the cost of working to a minimum.

The automatic "cut-out" is very simple. It consists of an electro-magnet, shown on the farther side of the solenoid, and wound with two layers of coarse wire, one end being connected to the core of the magnet, which is insulated, and the other to the resistance strip and to negative terminals. A flat headed iron screw, passing through the lever, comes over the magnet-pole, but does not touch it until the solenoid pulls the lever down past the feeding point, which it would do if the upper carbon holder sticks. In this case the solenoid would draw down the lever until the flat headed screw made contact with the magnet core. The lamp would then be cut out, the current passing through magnet-core, its two coils and the resistance to negative terminal, and the cut-out magnet would hold down the lever so long as the lamp failed to feed. If the carbons make contact again the spring overpowers the cut-out magnet, draws up the lever, and the arc is re-struck. The lamp is automatic in all its functions. The small slanting brass wire on the lever is used in trimming the lamp when the case is on. By pulling the little knob on the left-hand side the lever is lowered and the upper carbon holder released.

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CORRESPONDENCE.

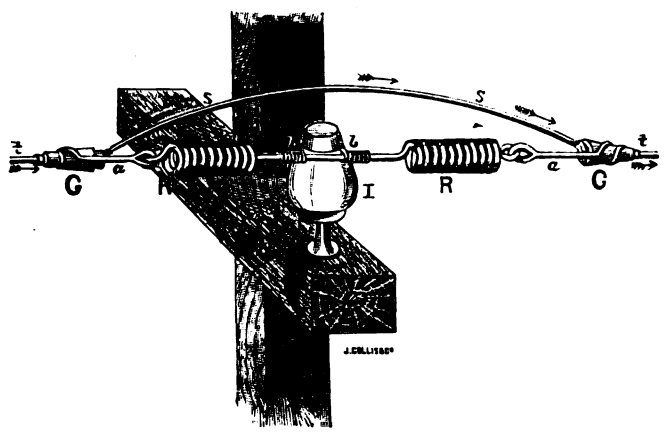
SPRINGS ON TELEGRAPH WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To-day my attention has been drawn to Prof. Perry's letter in your issue of the 30th ult. On the 1st ult. I entered at the Patent Office my invention entitled "Flexible Supports for Telegraph Wires." Half a week later, singularly enough (having, as he has since informed me, for some time worked at the subject), Sir Frederick Bramwell suggested this thing at Manchester; and those electrical and engineering weeklies which published my invention in their list of patent applications published in the very same issues a report of the B.A. meeting at Manchester, with Sir F. Bramwell's suggestion and the discussion ensuing.

On reading this report I at once wrote Mr. Preece and Sir F. Bramwell, informing them of my patent application, over which I had been long busy.

The precise method suggested by Sir F. Bramwell is included in my specification amongst a variety of methods effecting the same objects. But the complete regulator preferred, after careful consideration of the electrical, mechanical, and practical requirements, is, as you will see from the enclosed sketch, different from the method suggested at Manchester, and not open to the objection urged against the latter by several speakers, viz., "that it necessitated two insulators."



R R, spring regulators. G G, automatic self-gripping clamps. The grip is caused by the counter tension of the line wire *t t* and the spiral clasp anchors *a a*, while the line wire *s s* is not in tension, but bent sideways and upwards so as to stand free of the insulator I, to which the regulator is bound by the wire *b b*. The rubber tubing and the flexible motion of the points of attachment G G prevent possibility of the wire chafing.

NOTE.—The electric current takes the path indicated by arrows, the wire being insulated by vulcanised rubber tubes where clasped by the clamps G G. Any leakage at G G passes through R R, and is again insulated by I, so that the only leakage which can occur at I is the *leakage of the leakage.*

I use the present single insulator, unaltered, as it stands; and, at the same time, while protecting the wire from storm stresses beyond its strength, its insulation is greatly improved, so that a wire supplied with these regulators is a better conductor than a wire of much larger gauge without them. Also, by this same method of suspension, I entirely prevent that transverse chafing of the wire at the insulators which now causes continuous and much more insidious and universal destruction than the temporary damage wrought by occasional storms.

I was glad that Mr. Preece at the B.A. meeting, as soon as he got to understand what Sir F. Bramwell meant, promptly withdrew the objection he at the outset advanced. I am likewise glad to observe that Prof. Perry in his letter withdraws to a large extent from the opposition he offered to the suggestion at Manchester.

The subject is one on which the best trained minds are extremely liable to err at the first blush, but which on closer scientific investigation leads to one irresistible conclusion, viz., that, for *copper* lines regulators are necessary and advisable, because at an *extremely moderate cost* they can be so applied as to vastly improve insulation and entirely prevent chafing, while doubling the strength and therefore quadrupling the life of the wire against storm stress.

Reference to meteorological records over a sufficient range of time will, I believe, prove that the frequency of storms is in inverse ratio to the squares of their intensities. Thus by doubling the elasticity of the line (as the regulators unquestionably would do) the periods at which overstraining storms may occur are placed at four times the interval of the periods at which overstraining storms (of half the intensity) do occur under the present system of hanging up the lines.

Prof. Perry is quite right in his contention that the springs suitable to regulate iron telegraph wires of 7½ B.W.G. would be too heavy and costly to come into general use. But iron telegraph wires are doomed to give place to copper, and the sooner they do so the better. It is not for iron but for copper wires the regulators prove suitable and also economical. These regulators will enable the 100lb. copper wire to fulfil all requirements much better than the 150lb. copper wire without regulators.

As to the tenacity and extensibility of the spring, they must be of course equal at least to the tenacity and extensibility of the line wire.

In dealing with copper lines it is quite easy, by increasing the number of coils of regulator spring, to make its extensibility considerably greater than that of the line wire without rendering the regulator unduly clumsy or costly. But by introducing too much extensibility into the regulator we should render the dip of each span inconveniently great during storms, and this is the consideration which renders it prudent to limit this extensibility. In plainer English, it is only by slacking down the span the regulators save the wire from excess of storm stress. But you may slack it down too much. During storms of wind the lines not only oscillate like pendulums with the alternations of wind force, but they are also liable to skip, writhe, and *flap*, in some small degree like flags or pennons, and to become entangled with one another. I believe the entanglement would not occur if all the wires on a span were hung exactly the same dip. But in the present practice of linesmen, variations and inequalities of dip occur from a variety of causes, but mainly from having copper and iron wires hanging on the same posts. The copper is of course almost inevitably tighter in winter and slacker in summer than the iron. Thus unequal dips occur which are during storms oscillating at unequal times, like pendulums of unequal lengths; hence entanglement and confusion. Telegraph engineers have already learnt to avoid one fruitful occasion of entanglement—viz., joints in the line wire, or projections of any kind, occurring at midspan instead of at insulators, and by such avoidance they have already largely reduced the evil. By adopting regulators they would secure uniformity of dip, and so avoid the chief remaining cause of entanglements. But the extensibility of the regulators must be limited to that of the line wire or something not much greater, or, so far as the mere question of entanglement goes, the cure might prove worse than the disease.

Prof. Perry has alluded to the relationship between the weight of springs and their elasticity; and I may be permitted to add that while the extensibility of helical springs is directly as the number of their coils, and the diameter of the spring and the gauge of its steel do not therefore determine the aggregate elasticity of the spring, yet this diameter and gauge do determine the elasticity of each particular coil—that is to say, the diameter and gauge settle the *unit* of extensibility, while the number of coils determines the number of units composing the aggregate stretching capacity of the spring. The elasticity of each coil is, in fact, as the cube of its mean radius, and (for round steel) inversely as the fourth power of its gauge diameter, and the ultimate tenacity of the spring is as the cube of its gauge diameter and inversely as its mean radius of helix. I make the tenacity of my spring regulator about 18 per cent. greater than that of the copper line wire, to allow for the more rapid corrosion of steel than of copper. The limit of elasticity occurs at nearly half the breaking stress. Steel of considerably less tenacity than 50 tons per square inch may suitably

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be used in the construction of regulator springs for copper wire lines.

At 22deg. F., a copper line wire weighing 100lbs. per mile, and strained up to one quarter of its breaking stress, in a span of 100 yards, if so coated with snow as to present to the wind twice as much resistance as the naked wire offers, will be unable to endure without overstrain a greater wind pressure than 7lb. per square foot. But the same line wire under precisely the same conditions will, if fitted with a regulator of less than 1¼lb. weight, including its appendages, endure 13lb. per foot wind pressure without overstrain, and by doubling the number of coils (which would not be equivalent to doubling the total weight) the regulator will enable the line to sustain, under same snow-covered conditions, a wind pressure of 17lb. per foot without overstrain. I recommend the shorter spring as meeting best all practical needs.

In support of what Prof. Perry has advanced I may, in conclusion, point out that if the calculator in preparing tables of dip and stress of wire catenaries at various spans and temperatures were to deal only with the expansion of the wire and neglect its elasticity, his results would grossly exaggerate the differences between winter and summer dip and stress, for an infinitesimal percentage of stretch due to elasticity makes a most material change in dip, and consequently in stress. For example, a copper wire, weighing 100lb. per mile, and having a normal length of only 299·7134ft., when stretched across a span of 300ft., will have a dip of 2·583ft., and will have a catenary length of 300·0593ft. Its stress at insulators will be 82·51lb., and owing to that stress it will have stretched 0·3459ft. Thus, we see a stretch of only $\frac{1}{11}$ per cent. causing a dip of no less than 2·533ft. This stretch will be due to this stress at any time of the year, irrespective of temperature. But, now, after the wire has been so fixed up let the temperature rise, say, 54deg. F. What will happen? The change of temperature will cause an expansion of 0·162ft. in the length of that copper wire. The effect of this extra length would be (if there were no counter influence simultaneously working) to lengthen the catenary from 300·0593ft. to 300·2213ft., and to increase the dip from 2·583ft. to 4·99ft., and to decrease the stress from 82·51lb. to 42·78lb. But while the expansion is thus proceeding to slack down the catenary, the resilience of the wire takes advantage of the decreasing stress to commensurately decrease the stretch; for of course the stretch cannot continue without the continuance of the stress which causes it. Thus the catenary resulting from this increase of length by expansion, and decrease of length by elasticity, instead of a dip of 4·99ft. and a stress of 42·78lb., has, in point of fact, a dip of 3·694ft. and a stress of 57·46lb.

There would be no material discrepancies between such calculations and facts if the calculator would remember that the coefficient of expansion and the modulus of elasticity are counter forces whose resultant is the catenary.

I state this not merely on theoretical grounds, but from close experimental acquaintance with the behaviour of steel wire catenaries of suspension bridges.—Yours, &c.,

Sunderland, October 8, 1887. FRANK CAWS.

THE LIGHTING OF WATERFORD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We beg to hand you copies of two paragraphs which have appeared in *Invention* on September 24th and October 15th respectively, and which speak for themselves.—Yours, &c.,

LAING, WHARTON AND DOWN.

8 and 9, Holborn Viaduct, London, E.C.,
15th October, 1887.

"GAS *v.* OIL: THE OIL LAMP TRIUMPHANT.—We are glad to be able to announce that the street lighting of Waterford (Ireland) has been most successfully carried out by the Defries Safety Lamp and Oil Company, petroleum lamps having replaced all the gas lamps formerly used in the streets. This triumph of oil lighting has been achieved in the teeth of the most obstinate opposition by those interested in gas, who have not only smashed a number of the new lamps every night, but positively threw the lamplighter off his ladder one night. There can be no doubt that oil lighting, with the present improved lamps and at the reduced prices of petroleum, is proving a most formidable rival to gas when carried out by competent parties, such as the Defries Safety Lamp Company."

"GAS AND OIL.

"TO THE EDITOR OF 'INVENTION.'

"SIR: Referring to an article appearing in your issue of 24th ult., headed 'Gas and Oil: the Oil Lamp Triumphant,' I would beg leave to explain this matter in its proper light.

"The oil lamps do not deserve the praise they receive, neither are they a success.

"The City of Waterford is not lighted by them, but by the electric light, which lights all the main streets. The oil lamps only light the smaller and outskirting streets, and they are not as well lighted as they were by the gas lamps.

"The electric light is supplied from a plant fitted up by Messrs. Laing, Wharton and Down, on the Thomson-Houston system, which deserves the credit of superseding the gas, which it does very creditably, giving a very steady and beautiful light.—Yours respectfully, "A CITIZEN.

"Waterford, October 10th, 1887."

COMPANIES' MEETINGS & REPORTS.

Australasian Electric Light, Power, and Storage Company (Limited).

The shareholders in this Company held their fifth ordinary general meeting at Winchester House, 50, Old Broad-street, on the 17th inst., under the presidency of Mr. B. H. Van Tromp.

The CHAIRMAN reminded them that at the last meeting the arrangement with the Edison Company was confirmed, and it had been carried out. By that arrangement this Company obtained the absolute right to the Edison patents in Australasia, India, and the Cape of Good Hope, a stock of plant valued at between £4,000 and £5,000, and book debts to the amount of about £3,000, of which they had realised something under £2,000. Those assets they had paid for entirely in shares of their Company, which would receive no dividend until the 1 per cent. had been paid on the ordinary capital of the Company. The arrangement had placed them in the position of command of the whole market in Australasia, India, and the Cape of Good Hope; it left them, in fact, practically without a rival in those parts. With respect to the plant referred to, he must confess that its value was rather illusory. It was somewhat obsolete, but they believed they would be able to use most of it. They found that the agents, who had been connected for years with the Edison Company, were somewhat asleep, and they had to rouse them up. They had appointed a very efficient agent in India, with his centre of operations in Madras, and they hoped to hear some good news from that district. As to the Cape, nothing had been done there for some time past. The condition of things there had been almost as bad, if not worse, than in Australasia, where, as he had already said, they now held command of the position. The arrangement with the Edison Company had been a cause of much anxiety to the Directors, but it was satisfactory to believe that it must eventually redound to the benefit of the Company certainly, and he believed also to the Edison Company. The crucial question to be considered by the shareholders that day was, What had become of the capital of the Company, and what had been the result of the five years' operations carried on by the Company? And he believed he would be able to prove that the thing was not so bad as would at first sight appear. They must remember that the capital of the Company in the first instance was £120,000 only. There were certain vendors' and founders' shares, but those they need not take into consideration at all. As he had said, they had practically to deal with a sum of £120,000; and what had been done with it? In the very first year of the existence of the Company no less than £83,000 out of that amount absolutely disappeared as follows:—£45,000 was paid for the patents and £30,000 in shares; the Vogel mission cost them £5,000, and they paid £5,000 for the option of buying the Sellon-Volckmar accumulator. That amount disappeared without any result whatever beyond the fact that the Company became possessed of certain patents. The consequence was that the Company had been working with a very small sum of ready money. Even had the whole amount been called up at once they would have had only £40,000 to work with, and either in meal or malt they had that money still. They had been working for five years, and he would now show them how the debit balance was made up. £10,000 was attributable to the Vogel mission and the Sellon-Volckman accumulator. There had been an exceptional loss this year of £1,101, owing to the failure of one of their agents—Fletcher and Co. There were other exceptional items, such as the Randwick installation, interest, and discount, which increased the exceptional losses this year to £4,846, so that the actual loss did not exceed £22,000 for the five years. Then the cost of the Colonial establishment was £3,393, less profit on sales and goods, and the Theatre Royal installation, £2,186. The actual loss on the past year's trading to the end of 1886 was £1,207. The general charges in London, including discount and other charges, amounted to £1,270. Putting all these items together, they had only really lost on the five years' trading, as he had said, £22,000, and they had more than that as really fair assets subject to realisation, time being allowed for the Company to take advantage of any improvement caused by the

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progress of the electric light. He put down their plant as being of the value of £15,000, but it ought to be worth very much more, judging by the amount realised by the sales taking place in Australia. Then they held shares in the Australian Electric Light Company to the amount of £18,000. Those shares they took as part payment of their patent rights in the City of Melbourne. The shares had been at par, but they had dropped down, and they were now said to be worth 7s. 6d. ; but the Company was now carrying on a lucrative business, and he hoped that the shares would soon reach par again. Another asset was the last call of 10s. upon which they had borrowed £5,000, leaving a balance for the Company from the call of £7,500. Those three items—stock £15,000, shares £18,000, and the call £7,500—made the £40,000. Their assets more than represented the loss they had made, and therefore they must still hope that the Company might eventually pull round and pay a dividend. He believed that opinion was shared by others in the room. With regard to their trading, the lighting of the Adelaide Exhibition had been a success, and had spread the celebrity of electric lighting throughout the colony. There would be a profit, he had no doubt, on that work, and they would be able to show that in their next balance-sheet. At the last meeting the Board were urged to see if some new arrangement could not be made whereby the standing charges of the Company could not be considerably reduced. That was a matter of great and deep interest to the Board, and they at once opened communications with Captain Rowan, their general manager in Australasia, pointing out to him most emphatically the necessity for reducing the charges. The Chairman detailed the course of the negotiations, pointing out the difficulty of dealing effectually with the matter, owing to the distance at which the correspondence had to be conducted, and said that it fortunately happened that Mr. Sanderson, one of the Directors, went out to Australia, and he kindly undertook to see Captain Rowan and look into the affairs of the Company generally. Mr. Sanderson took an immense deal of trouble, and the Board were very much indebted to him. He returned with certain proposals, and ultimately an agreement was made, but the matter was so delayed on certain small technicalities that the agreement was not made binding until August last. The consequence was that although the new arrangement was now in operation he feared that the accounts for the current year would not greatly benefit from the arrangement, but for the future it was certain to be very beneficial for them, inasmuch as the fixed charges could not exceed £682 for the 12 months. It would be very hard indeed if they could not get sufficient profit to pay that amount, and Captain Rowan would get nothing unless they did a volume of business which showed a larger income than the sum he had mentioned. In regard to the London expenses they had been reduced, and they would be further reduced. The services of Mr. Duncan, of the staff, and the office expenses, did not amount to many hundreds a year, and he could not imagine that the business could be carried on eventually, and to the interest of the Company, at a less expenditure than at present. With regard to the future, any gentleman in the room who was interested in electric lighting must be greatly delighted at the enormous progress that had been made throughout the world in the last year in regard to the light. In America over 30 millions sterling had been invested in the electric light industry, and nearly all of that amount was earning a dividend. As to Europe, there had been such a stir as to the immense importance of lighting large buildings with electricity that he believed within a year not a single theatre of any importance in any capital of Europe would be without it. He knew that in some countries they had made the existence of the theatres conditional on the use of the electric light. He had been much struck by reading the other day a lecture on electric lighting which was delivered by Prof. Forbes recently before the British Association. As they were aware, the progress of electric lighting in this country had been retarded in consequence of adverse legislation. Having quoted from Prof. Forbes's lecture, he said that what had been always urged against electricity was its enormous expense, but from what he had just read they would see that in the opinion of a man of eminence in the electrical world there was no reason why electric lighting should not be supplied to every town in the United Kingdom at the equivalent of 3s. per thousand cubic feet of gas. He (the Chairman) was speaking in the presence of a gentleman who was deeply interested in electricity, Mr. Ince, who was connected with the company that was supplying the electric light at the Grosvenor Gallery. That company was recently started with a capital of a million. They were putting up a magnificent station at Deptford with immense machinery. At that moment the company was supplying 20,000 lamps in London at a profit, and so eager was the desire for the light that as soon as they were ready, there was no doubt they would be able to light 40,000 lamps every night. Supposing they only realised a profit of 3d. a night, the shareholders would see how much that would represent in the course of the year. With the commanding position they now held, the arrangements they had made for reducing the charges, and their improved prospects owing to the progress of the electric light, he thought that there was a good future for their small Company. He did not for a moment believe that they would think of winding up the Company, but if they entertained such an idea they must remember that the very first thing the liquidator would do would be to call up the 10s. a share, and therefore as they knew that that was all they were liable for, the best thing they could do even in that view was to put off the evil day as long as possible, especially in view of their improved prospects. The day might come when the Directors would ask the shareholders to pay up the call, but if so they might depend upon it that it would be because the Directors believed that there was a good opportunity of investing the money advantageously. All the Board were agreed that if they could succeed in laying out this money in establishing a first-class lighting station in a large city, with a gradually but surely increasing business, that that was the best thing that they could do, and he thought that that would be the proper way in which they should lay out their money. They would only do so in a town where they had a perfect right to do so, and where they could not be interfered with, and where at a certain price they would realise a profit. He believed that it was the opinion of the whole world that the electric light was the light of the future, and he also firmly believed, that which he had believed ever since he saw the electric railway at the Crystal Palace eight or nine years ago, that it would be the future motive power. There were now no fewer than thirty electrical railways and tramways in full operation. There were thousands of ways in which electricity could be used in addition to electric lighting. All this was open to them in Australasia. There was no reason why, if it were desired to work a tramway there by electricity, the Company should not supply the machinery. In Genoa, Padua, Milan, Vienna, Paris, in all the principal towns of Europe, in St. Petersburg at that moment, every theatre was closed except a small one where French plays were given. Why was that? First, because the theatres must be altered to increase the facilities of ingress and egress, and it was a *sine quâ non* that the electric light must be supplied. He felt convinced that this progress of electricity which this state of things indicated must extend to Australia. It was true that the electric light had been progressing there for the last two years very slowly, but the Company would have done much more but for the drought and a desire on the part of the Australian people not to embark on any new undertakings. The Board would be most happy to answer any questions, for he could assure them that there was nothing whatever to conceal, and that there would be no secret from the shareholders. He concluded by moving the adoption of the report and accounts.

Mr. J. J. CATER seconded the motion.

Mr. GUESDON thought it would be more advantageous for the Company to call up the 10s. a share and pay off the £5,000 which had been borrowed against it, seeing that they were paying interest on the amount.

Mr. INCE said he fully acquiesced in the view of the Chairman in thinking that the future of the Company was not without hope ; in fact, he himself would venture to go further, and say that if the shareholders would pull with the Board, as he trusted they would, the future of the Company would yet be a success. There was no doubt that when they started the Company, in which he was a very large shareholder, it was imagined that a great deal more was known about electrical science than was known. They were practically at that time not in a position to deal with the lighting from large central stations ; they were not in a position to distribute the electrical current at a distance through mains of such size as to be sufficiently economical to leave a profit. That difficulty had now disappeared, and it was now possible to transmit electricity economically through mains of such size that they could light not only the whole of London from one centre, but a city much larger than London was, or was ever likely to be. As to the remark of the last speaker, he thought that in the present position of affairs the Board had acted wisely in borrowing a certain sum of money at interest rather than call up the balance due from the shareholders. He thought that this matter should be left *in statu quo*. They had not now to put before the shareholders any hypothetical case, or to state that they had certain patents, and that they "believed" certain things could be done. Central stations had been started in England and America, and in both countries they were a great success. They were yielding profits with which the shareholders were satisfied on both sides. In the company with which he was associated he certainly anticipated a dividend such as would thoroughly satisfy all the investors in it. He could see that the time would come when the Board would have to ask the shareholders to meet them by subscribing a certain further amount of capital than that which they already possessed. He ventured from his own knowledge of the subject to be prophetic, and to say what sum they ought to ask for in the first instance. Taking the capital of the Company roughly as representing £200,000, he thought that in order to start a central station, which would leave such a return as would thoroughly satisfy the shareholders, the Directors ought to look forward to increase their capital by 10 per cent. ; and when they asked him to subscribe his proportion he would come forward readily and do it, and he trusted that the other shareholders would follow suit. He believed that the capital so raised could be invested in Australia to yield a profit of 20 per cent., having regard to the price of gas, and once they started such a station they would have no difficulty in establishing others from which the profits would be equally great. He firmly believed that if they would help the Directors the whole of the present capital, which was now worth practically nothing, would become valuable. In the case of the undertaking with which he was connected they were selling the current at a price equal to 4s. per thousand cubic feet of gas, and at that price it was being taken up very rapidly. He could see that as the number of lights taken from the central stations increased to a great extent it would be quite possible to reduce the price to 3s. He ventured to be prophetic, and to say that the electric light even at the present price was going to stamp out gas as an illuminant, and more than that, he believed that the time would come when the electric light would snuff out gas, not only by reason of its superiority, but because it was cheaper than any gas now supplied in the City of London.

Mr. VERITY said that being an Edison shareholder he was not conversant with what had gone on in the Australasian Company generally. When the arrangement between the Company and the Edison Company was made he said he thought it was a bad bargain for the latter, but now that they were members of the Australasian Company, seeing that they held the whole of the patents for Australasia, India, and the Cape, he thought that their position was a good one. The Directors had great difficulties to contend with, but the share-

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holders really must ask them to do their utmost to prevent the lamentable loss every year which they had hitherto sustained. He dissented from the proposal that they should establish central stations, because they did not hold the patents that were requisite. He thought that the Company should simply sell its dynamos and lamps—to do, in fact, what the Edison and Swan Company did. That company were giving up their installations, and were selling their lamps and dynamos.

A SHAREHOLDER asked whether some of the shares were not fully paid up already.

The CHAIRMAN, in reply, said that all the shares that were issued to the Edison Company as a consideration for the purchase of their assets were fully paid up, and so also were the shares which were issued to the vendors of the Brush patents to the Company. As regarded the capital of £120,000, however, all of those shares had a liability of 10s. each.

Mr. M'MILLAN said that he thought that the course before the shareholders was perfectly clear, and that was to support the Directors. He could not agree with the observation that had been made that it would be politic for the Directors to call up the 10s., for the very fact of there being 10s. to call up gave the Directors a better opportunity of exercising a certain amount of credit. He was perfectly satisfied to accept the statement of the Chairman and patiently to await the issue of events. Possibly the undertaking might turn out a great success, but the worst that could happen would be the loss of 10s. a share.

Mr. SANDERSON, at the request of the Chairman, then addressed the meeting, especially in regard to the arrangements which he had made with Captain Rowan, and the result, as already intimated by the Chairman. He expressed his opinion that in Captain Rowan the Company had a most able representative. With respect to their investment of £18,000 in the Australian Electric Company of Melbourne he saw a great deal of the members of that Board when he was in Melbourne, and it was a Company which had every element of success in it. They were lighting the Princess's Theatre and the Theatre Royal, and he was sure that all their customers were exceedingly well satisfied. He believed that a lighting station at Sydney would pay very well, and that if they had a station there when Australia was successful and had plenty of money it would be a great success. He had on his return from Australia visited India also, and he thought they had very good prospects in India also, and altogether, in view of the great strides which had been and were being made by electric lighting in England, he believed that the progress would extend to India and Australia, and that a dividend would come to them soon.

The CHAIRMAN, in reply, at the close of the discussion, said that the principal profit they had made in Australasia had been from the dynamos and other plant they had sent out, not from the lamp patents. He had been very glad to see Mr. Verity among them, for that gentleman had turned his attention to and believed strongly in the electric light as the light of the future. If electricity had preceded gas, the electric light would have been in every town long before now, but it had had the enormous monopoly of gas to fight against. That, however, was breaking down. In the City of Christiania the Corporation were the owners of the gas works, and they had determined to abandon gas except for cooking and heating purposes, and to supply the the whole of the city with the electric light. He believed that the same would be done in England yet; in fact, it had been done at Leamington, which had decided to abandon gas and to adopt electricity for the whole of the town. If they could see their way of profitably increasing the capital by 10 per cent. they would be prepared to do so at the proper time. He regretted that Major Flood Page was absent, owing to an accident which had confined him to his room. He was a most able Director of the Company. He then put the report, and it was unanimously adopted.

On the motion of Mr. SANDERSON, seconded by Mr. INCE, Mr. Latimer Clark, C.E., and Mr. Philip Falk were unanimously re-elected Directors of the Company; and the auditors (Messrs. Deloitte, Dever and Co.) were also reappointed.

Mr. M'MILLAN then proposed, and Mr. INCE seconded, a vote of thanks to the Chairman and Directors, which was unanimously agreed to.

The CHAIRMAN acknowledged the vote, and said that the Directors would do their utmost to promote the welfare of the Company.

The meeting then terminated.

The Water Primary Battery Company.

We take the following from the *Financial News* of the 14th inst.:—

The ordinary general meeting of the Water Primary Battery Company (Limited) was held on Tuesday, at 265, Gresham House, Broad-street, E.C., Colonel G. B. Malleson, C.S.I., presiding.

The notice convening the meeting having been read by Mr. W. H. Smith,

The CHAIRMAN said: Gentlemen, I have very great pleasure in introducing to you the inventor of the water battery, Mr. D'Humy, who is a very old friend of mine, for I have known him many years, and know he is a gentleman who possesses one of the most inventive minds in Europe (applause). No single invention of his have I seen which is not capable of practical application (applause). With regard to this Water Primary Battery I have taken various engineers of my acquaintance to the office with the express idea on my part that they should be able to pick a hole in it; but not one of them has succeeded in that (hear, hear). Gentlemen, with these few remarks I shall call on Mr. D'Humy to address you on the points which he may consider necessary.

Mr. P. R. DE FAUCHEUX D'HUMY said he would do his best to give as clear an explanation as possible. Last year, on December 23rd, he formed a company with a capital of £100,000 in fully paid-up shares, £20,000 being given to him as the vendor, as well as the shares in payment for all plant, machinery, and stock, and also for the English, French, American, Indian, Belgian, Austrian and Italian patents of the Water Primary Battery. He started the company without calling any capital from the public, and to show his confidence in the invention he had paid all the expenses up to now to bring the Company to its present success, and he had acted as an ordinary traveller, instead of the Managing Director of the Company, in trying to obtain orders. Since December 23rd he had manufactured a big battery, to be demonstrated at 26, Gray's Inn-road, as a specimen of a central station battery for lighting a number of houses. For ten months this battery had been going day and night, and he had invited the public and all the scientific world of Europe to visit the place and inspect it. For ten months it had been working with no need for repair. The invention had made some sensation in Europe. Municipalities and Governments had sent their engineers and confidential men to report on it, and it had given satisfaction to everybody (applause). It had been proved that the battery could be worked as well as the dynamo, and that a large field was open to it for supplying electric light (applause). He had succeeded in obtaining very important concessions for it in various big cities, and on Sept. 16th last he had obtained a concession for lighting Madrid by electricity—and about 200,000 lamps would be required within the next four years—and had given the contract for the execution of the said work to the Water Primary Battery Company (Limited) (hear, hear). Official document and decree were now before the Chairman. He had sold the patent for France for £100,000, which was to be paid by a syndicate, according to French law—that was to say, a fourth of the amount would be paid almost immediately. Since he sold the French patent he had received a letter from France telling him that the syndicate were obtaining orders very rapidly (applause). This Company would be the contractors for the French company, supplying all the water battery appliances, and the transaction would be very profitable. This Company, he pointed out, had started with no capital, and their manager had never received a salary, but working as an ordinary clerk he had succeeded in making a very good report, and was able to say that next year on the original capital of £100,000, the shareholders would receive a dividend of about 100 per cent (cheers). For years he had carried on a fight with engineers and scientific men of Europe. Nobody would believe that from water the power to light by electricity could be obtained; but he had proved that with water and a metal that did not destroy—that was to say, with common iron plunged in water—he could obtain a result that was reputed in the scientific world to be impossible (cheers). Every week for ten months he had had 600 or 700 people at his office to inspect the invention, and he had shown to the engineer how to distribute the electric current with no mechanical difficulty, and proved to the uninitiated on the subject how he could manufacture his own electricity at his home. Lately he had made another invention, which would, he was sure, be very popular in all Europe, and he had been offered £30,000 for the patent in France. It was a very small battery, and he had received applications for it in reference to one, two, three, four, and ten lamp-power for lighting very small houses and small workshops. He had given a long course of study to the subject, and to-day the invention was complete. It consisted of a little battery which was automatic, and capable of working for many years. The problem had been solved with the water battery, and the two inventions had become very popular in the world. He had established the water battery in the confidence of contractors in the north of England, and had succeeded in getting a staff ready to manufacture the water battery and the small battery on a large scale. The company possessed in the North of England a very large amount of business, and had made a contract with an important firm for the manufacture of both batteries, viz, with Messrs. J. Butler and Co., of Stanning'ey, near Leeds, who had so much confidence in the future of the invention that they had not hesitated to take shares and debentures as the consideration, so that for the present this Company was in a position to form several large centres without expending a single shilling (applause). Propositions had also been made by another important contractor who was desirous of joining the contractors in the north and working with them, and had offered a large sum of money to enter into the concern. This, he thought, was all he had to explain.

Mr. W. H. SMITH asked Mr. D'Humy to give some further explanation as to the concession at Madrid.

Mr. D'HUMY said that concession did not belong to this Company, but to him personally; but he had transferred the work, under contract, to the Company, and they would make a large profit out of it—£25,000 or £30,000 (cheers). He was also negotiating for the sale of the patent at Belgium, Austria, America, and other countries, and these sales would also bring some important profits to this Company (cheers).

The CHAIRMAN said it had occurred to him while Mr. D'Humy had been speaking that the success of every enterprise depended on the fact that the basis of it was sound and valid. He did not know whether all the gentlemen present had seen the water battery at work, as he had, but if anyone had the slightest doubt of the validity and value of the machine, and its ability to effect what Mr. D'Humy said it could, let him put any questions to that gentleman, and he would, no doubt, answer to his own satisfaction and to the satisfaction of them all.

Colonel INNES said he did not profess to know anything about electricity, but some months ago he made an examination of the invention, and was very pleased with everything he saw. But in making inquiries in reference to the lighting of the Chesham Gallery, Old Bond-street, he went to three or four firms, and in discussing this Company's invention one man, a thorough electrician, declared the plates would never last. He should like some explanation on this point.

Mr. D'HUMY said in the water battery there were two kinds of plates—one iron, the other carbon. The objection referred to the carbon plate. Undoubtedly, if there were any silica in the carbon plate it would perish;

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but in his invention there was no silica, but pure carbon, and therefore it was indestructible (hear, hear).

Mr. DAWSON PHILPOT said when he had denied that there was any decomposition of metal, he was met with the reply that in that case there could be no light.

Mr. D'HUMY said instead of a decomposition of metal there was a decomposition of nitric acid, which was enclosed in a reservoir in the machine. A pound of nitric acid cost 2d., and would produce light for 15 lamps of 10 candle-power each (hear, hear).

Mr. OXLEY raised a question as to the business now in hand, in reply to which,

Mr. W. L. MAITLAND stated that he had the business of the Company in hand only a little over a week, and in that time he had obtained for Mr. D'Humy close on £15,000 worth of orders (cheers). His fear was that they would not be able to supply all the customers he could bring them.

A SHAREHOLDER: The orders are chiefly to do with theatres, I think?

Mr. MAITLAND: Yes, and other large buildings. Two large contracts have been closed, and two will be closed within a week, and two others also within a week, for large stores.

The CHAIRMAN: That is very satisfactory; but it will be still more satisfactory if Mr. D'Humy tells us he will be able to supply all orders rapidly.

Mr. D'HUMY: Oh, yes; we have the contractor in this room—Mr. Butler—who has more than 1,000 men at work in his factory, and will be able to manufacture very rapidly so as to supply the demand.

The CHAIRMAN said it had been suggested to him that Mr. D'Humy should explain to the meeting the working of the battery; but his answer to that was that it would be far better if gentlemen who had not seen the works should go and see them. He was sure Mr. D'Humy would explain on the spot the mode of working and the principle on which the work was carried out (hear, hear).

Mr. D'HUMY: With the greatest pleasure. Replying to a question as to the price of the light supplied by the Company, Mr. D'Humy said the battery would supply the light at exactly the price of gas. If the Company only supplied the light it would leave them a small profit (cheers), but it would be quite the exception that they supplied the light without the battery. For a very small installation the cost would be 10 or 15 per cent. above the price of gas.

Mr. W. H. SMITH moved a vote of thanks to the Chairman for his kindness in attending the meeting. He knew Colonel Malleson's engagements were such that it was very difficult to get hold of him; but they also knew that he was always ready to help on any scientific object for the benefit of the world in general (cheers).

The CHAIRMAN said he thought their thanks were due rather to Mr. D'Humy for the explanation he had given (cheers). He thought they must have been struck with wonder and admiration at the ease with which the light could be produced under the Company's system, and which when produced by the ordinary way of dynamo, caused great disturbance in private houses, and a great deal of unpleasant noise in larger premises. He was sure that those who went to see the battery would go away with wonder at what science could do, especially in the hands of such a skilful man as his friend Mr. D'Humy.

The proceedings then terminated.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

Report and accounts of the Directors for the half year ended 30th June, 1887, to be submitted to the twenty-eighth ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, the 26th inst., at 2 o'clock:—

The usual statements of account for the half year ended 30th June last show that the gross receipts, inclusive of Government subsidies, have amounted during that period to £219 201. 4s. 8d., against £224,843. 0s. 1d. for the corresponding half year of 1886. The working and other expenses, including £26,408. 9s. 7d. for cost of repairs to cables and expenses of ships, absorb £76,241. 3s 6d., against £81,775. 7s. 1d. for the corresponding half year of 1886, leaving a balance of £142,960. 1s. 2d. From this is deducted £3,702. 16s. 5d. for income-tax, and £41,595 for interest on debentures and contributions to sinking funds, leaving £97,662. 4s. 9d. as the net profit for the half year, against £97,480. 5s. 8d. for the corresponding period of 1886. One quarterly interim dividend of 1¼ per cent, amounting to £31,250, has been paid during the half year, and another of like amount was distributed on the 15th inst., leaving £35,162. 4s. 9d. to be carried forward. In accordance with the provisions of the trust deed, dated 10th May, 1879, 264 Five per Cent. Australian Government Subsidy Debentures were drawn on the 29th April last, for the payment at par on the 1st July. The numbers of the drawn debentures will be found on page 12. The Company's maintenance ships have been kept employed on various cable repairs during the half year under review, but no interruptions of a serious nature have occurred. The Company's hulk "Southern Ocean," stationed at Singapore during the last eight years, having been reported to be unsafe as a floating cable establishment in consequence of ravages of white ants, the vessel has been dismantled, and the machinery and cable tanks removed therefrom to the Company's new shore cable establishment at Singapore. The hulk has since been sold by public auction. The subject of reduced tariffs between Europe and the Australasian Colonies was discussed at the Colonial Conference recently held in London, and the proposals submitted by the Company based upon a Colonial guarantee or subsidy are now before the Colonial Governments. The South Australian Government land line between Port Darwin and Adelaide has, as usual, been satisfactorily maintained during the half year under review.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—At a meeting of the Board of Directors of this company held on the 14th inst., it was resolved "to declare an interim dividend for the quarter ending 30th September, 1887, of 7s. 6d. per cent. on the ordinary stock, and 15s. per cent. on the preferred stock, less income-tax, payable on the 1st November to the stockholders registered on the books of the company on the 7th October, 1887."

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 17th October amounted to £3,566.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY.—The directors have resolved to pay an interim dividend at the rate of 5 per cent. per annum in respect of the current year.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announces the payment, by interest warrants, on the 1st November next, of interest for the half-year ending the 31st October, on their Four per Cent. Mortgage Debenture Stock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 14th October, 1887, were £2,752, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 15th October are £2,629, as compared with £1,863 in the corresponding period of 1886.

PARTNERSHIP.—Mr. J. F. La Trobe-Bateman informs us that he has taken into partnership with him his son, Mr. Lee La Trobe-Bateman, and also the Hon. Richard Clerc Parsons. Mr. Parsons' name is well known to electrical engineers in connection with the high-speed turbine steam engine.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 19.		BUSINESS DONE WEEK ENDING OCT. 19. Highest.		Lowest.	
Anglo-American	37,	38	37½		37	
Do. Preferred	60½,	61½	61¾		60¾	
Do. Deferred	14,	14½	15		14½	
Brazilian Submarine	11½,	11½	11½		11	
Cuba	11⅝,	12¼	12¼		—	
Do. Preference	18,	19	—		—	
Direct Spanish	2⅞,	3¼	—		—	xd.
Do. Preference	8,	9	8½		—	
Direct United States Cable	8⅞,	9¼	9 3-16		9	xd.
Eastern Telegraph	11,	11½	11¼		11	xd.
Do. 6 per Cent. Preference	14,	14½	14½		—	xd.
Do. 5 per Cent. Debentures, 1899	106,	109	—		—	
Eastern Extension	11½,	11¾	11¾		11⅝	xd.
German Union	10½,	11	—		—	
Globe Telegraph and Trust	5⅞,	6⅛	5 9-16		5⅛	xd.
Do. Preference	13⅛,	13⅜	13⅜		13⅛	xd.
Great Northern	13½,	14	13⅜		13⅜	
Indo-European	86,	88	—		—	
Reuter's	7⅞,	8¼	—		—	xd.
Submarine	170,	180	177½		—	
West India and Panama	⅝,	¾	—		—	
Do. 1st Preference	9½,	9¾	—		—	
Western Brazilian	7⅜,	7⅝	7⅝		7⅜	xd.
Western Union 7 per Cent. 1st Mortgage	120,	125	—		—	
Do. 6 per Cent. Sterling Bonds	101,	104	—		—	

TELEPHONES.

Consolid. Telephone and Maintenance	11-16	13-16	—		—	
Oriental	5-16	7-16	—		—	
United Telephone	11½,	12	11⅝		11 13-16	
United River Plate	4⅜,	5¼	—		—	xd.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	2¾	—		—	
Do. (fully paid)	3,	4	—		—	
Swan	1½,	1⅝	1½		—	
Maxim Weston	3-16,	5-16	—		—	

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37½		37	
India Rubber, Gutta Percha, and Telegraph Works	21,	22	21½		20¾	

THE ELECTRIC APPARATUS COMPANY, Limited.

Head Office and Warehouse: 50, Bow Lane, Cheapside, E.C.
Depots: 4, Charing Cross, S.W., and 65, Faulkner St., Manchester.
Works: Arnold Road, Bow, E.

Electric Light Fittings, Edison-Swan Lamps, Schuckert's Ammeters, Voltmeters and Speedometers.

Specially Low Quotations for Electric Light Cables.

BELLS, INDICATORS, BATTERIES, WIRES, &c.

MEDICAL APPLIANCES.

SHIPPERS AND THE TRADE SPECIALLY STUDIED.

NO CONNECTION whatever with any Firm trading under a SIMILAR TITLE.

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NOTES.

DISTURBED IRELAND.—Again, on Sunday night last, the telegraph wires were cut, this time between Kilrush and Ennis.

GOLD MEDAL AWARD.—Messrs. Ransomes, Sims and Jefferies have received the highest award—a gold medal—for their exhibits at the Charkoff Exhibition.

PALENCIA (SPAIN).—The municipality of Palencia announces that it is proposed to receive tenders for lighting the streets of that town by electricity. The present cost of gas lighting is a little over £500 per annum.

TURKEY AND GREECE.—The Post Office announce that telegrams are now transmitted by the route of the Eastern Telegraph Company to Turkey at a charge of 10d. per word, and to Greece and the Greek Islands at 7½d. per word.

BOOKS RECEIVED.—"On a Surf-Bound Coast; or, Cable Laying in the African Tropics," by Archer P. Crouch, B.A., Oxon. London: Sampson Low.—Also from Messrs. Longmans, Green and Co. a copy of "A Handbook for Steam Users," by Mr. M. Powis Bale.

THE "EMPIRE" MUSIC HALL.—The electric lighting contract for this gigantic building has been placed in the hands of Mr. Harry South, of 10, John-street, Adelphi, W.C. Engines and boilers of over 100 horse-power are to be erected, and some 1,200 incandescent lamps will be run.

THE FRENCH INSURANCE OFFICES.—In consequence of the catastrophe at the Opéra Comique, and notwithstanding the fact that electric light is now compulsory in the Parisian theatres, the French Fire Insurance Offices have given notice of an increase in the tariff for the insurance of theatres.

THE GÜLCHER COMPANY.—We hear that at the present time this company is busy in all departments, having received several important contracts, amongst others, for 64 arc lamps for the Olympia Hall, the lighting of the new markets at North Shields, and three mills in Yorkshire, besides several small contracts.

AN INQUIRY.—The New York *Engineering and Mining Journal* mentions that it has recently had an inquiry, coming from a district where fuel is scarce and water-power cheap and plentiful, as to whether it would be possible to employ the latter power to obtain heat for the purpose of roasting ore by means of the electric current.

THE ATLANTIC CABLES.—A number of rumours relating to a further amalgamation of the several Atlantic Cable Companies, and a possible increase of the tariff, have been going the round of the financial and daily press for some time past. We have reason to believe that none of these statements are published on authority, and that they are for the most part purely conjectural.

THE LIGHTING OF THE CITY.—The Paving Committee of the St. Saviour's Board of Works has recommended the Board to accede to the application of the Anglo-American Electric Light Corporation for permission to carry their mains under the footway of Blackfriars-road, on condition that the company should supply light in that district on the same terms as elsewhere.

TRENTE (TYROL).—The Municipality of the town of Trente, in the Tyrol, has under consideration a scheme for lighting the streets by electricity, motive power being obtained from the falls at Fersina, a distance of 2½ kilometres. These falls are about 25ft. in height, and the current is sufficient to yield from 400 to 800 horse-power according to the season. The estimated cost of the installation is about £8,500.

ELECTRIC SAFETY LAMPS IN MINES.—From a letter addressed to *The Times* on Friday last by the secretary of the Edison and Swan Company, we learn that the trials of their lamps in the Risca pits, commenced last April, have proved so successful that Messrs. Watts, Ward and Co. have ordered 2,400 electric safety lamps to be manufactured, with a view of superseding all the existing lamps in their extensive South Wales collieries.

THE FRENCH TELEGRAPHS.—M. Coulon, the Director-General of Posts and Telegraphs in France, has summoned a commission of the higher officers of the establishment to consider amongst other matters the following important questions:—The employment of the system called steno-telegraph, by which messages are transmitted by stenographic signs; the introduction of multiplex telegraphy; the use of the electric light in telegraph offices.

THE PRICE OF GAS.—We notice with satisfaction the announcement that the price of gas in that part of the metropolis situated north of the Thames will be reduced on the 1st January next from 3s. per thousand to 2s. 9d. per thousand. While not in any way hindering the progress of electric illumination, this reduction will diminish the cost of working gas engines, by means of which a considerable amount of electric lighting is at present maintained.

A CHANCE FOR THE YOUTHFUL GENIUS.—The *Société Industrielle d'Amiens* announces that it is prepared to award an indeterminate number of gold medals (value 200 francs) for as many essays dealing with any department of theoretical or applied electricity as may appear to possess sufficient merit. Manuscripts, which must presumably be written in French, should reach the President of the Society at No. 29, Rue de Noyen, Amiens, on or before 30th April, 1888.

NEW YORK ELECTRICAL CLUB.—At the monthly dinner of the New York Electric Club, announced to be held on Thursday, October 20th, the topic of the evening, to be introduced by Prof. Leonard Waldo, of Yale College, was the question, "What is an Electrician?" We learn with satisfaction that Prof. Waldo "proposed to look at the question from the standpoint of establishing something of the professional *esprit de corps* of the legal or medical profession."

TAMPERING WITH TELEGRAMS.—At the Central Criminal Court on Monday, Harry Wilkes, telegraph clerk at the General Post Office, having pleaded guilty to the charge of altering certain racing telegrams received by him from Sandown, was sentenced to one month's imprisonment. The lightness of the punishment is explained by the prisoner's youth, and the fact that he had been tempted by betting men much older than himself, and apparently not to his own profit.

CUTTING GLASS TUBES.—E. Beckmann in the *Zeitschrift für Analyt. Chemie* gives a neat method for dividing glass tubes which are too large or too thick to break with a mere file nick. He scratches round with a file at the line where the division is required, then wraps around the tube on each side of the mark a strip of wet filter paper and applies a Bunsen burner, or, better, a blow-pipe flame. The method is equally good for the thickest glass tubes and the thinnest beakers. The space between the strips of filter paper should not be more than one to two millimetres.

INTERNATIONAL TELEPHONE SERVICE.—Some little while ago we recorded the fact that arrangements were being made

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for the establishing a system of international telephonic communication between neighbouring towns in Western Germany, Belgium, Eastern France, and Switzerland. Mulhouse and Bâle have already been connected, and financially the experiment gave every promise of success. Suddenly, however, the German Government has announced its intention to withdraw entirely from the scheme, and the lines already erected will be abandoned. Political reasons are supposed to have dictated this measure.

THE HAMMOND ELECTRIC LIGHT AND POWER SUPPLY COMPANY.—We publish in another column a report of the meeting yesterday of this company. From the statement made by Mr. Wm. Theobald (the liquidator) it will be seen that great difficulties had to be contended against, but considerable judgment was brought to bear upon them, and with a result which, under the circumstances, cannot be regarded as other than satisfactory. At one time it was feared that the creditors might not be paid in full, but their claims have all been discharged, and there is to be a return to the shareholders of 3s. a share.

A GEISSLER TUBE PHENOMENON.—M. Kündt, whose researches on electro-optical phenomena are familiar to the student of "advanced" physics, has recently examined the metallic layer which is frequently found in a Geissler tube from the material of the negative electrode, and he finds that it possesses the property of double refraction. Viewed by transmitted light these layers, which are of excessive tenuity, have the following colours :—

With gold electrodes	.....	Green, slightly bluish.
„ silver „	.....	Blue, slightly violet.
„ copper „	.....	Dirty green.
„ platinum „	.....	Greyish blue.
„ iron „	.....	Grey.
„ nickel „	.....	Grey.

The least trace of oxygen in the tube produces a deposit of the oxide, even with gold, silver, or platinum, although the electrode itself remains un oxidised. By reflected light under oblique incidence Newton's rings are seen. Further information on the subject may be found in *Wiedemann's Annalen*, Vol. XXIX., p. 353.

DISTRIBUTION OF TIME IN AMERICA.—Time is transmitted every day from Washington to the chief ports of the Atlantic seaboard. From three minutes before noon till the stroke of noon the time is sent, second by second, with the exception of those which mark each half-minute and the five seconds which precede the exact minute. The Western Union and Baltimore and Ohio Telegraph Companies (recently united) give up the use of their wires free of indemnity for this purpose. Wherever the time is sent, an electro-magnet gives the signal sent from the distributing saloon in the Washington Observatory. At noon precisely the electric current drops time-balls at New Orleans, Savannah, Washington, Philadelphia, New York, Newport, and Woods Holl, in Massachusetts. Boston is served directly by the Cambridge Observatory. The Pacific ports are supplied from an observatory at Mare Island, near San Francisco. Private and institutional clocks are also corrected by the time currents. Some establishments, such as the fire stations, the signal office, and the coast survey, have direct telegraph lines by which they can get the hour at any time. There are many manufacturers, clockmakers, and others who subscribe for it.

THE INSULATION OF ELECTRIC LIGHT CONDUCTORS.—Writing on this subject in *L'Electricien*, M. Hospitalier makes the following very truthful observations :—"Theoretically speaking nothing is more easy than to define the insulation resistance of any system of electric conductors whatever ; but nothing, on the contrary, is more difficult, in practice, than to determine the insulation of such a conductor under conditions which correspond exactly to those of its employment. We lack a method simple and practical which shall permit the comparison of different samples and give a just and fair appreciation of their respective values. Some are content to indicate the insulation required in a manner purely sentimental, without being concerned with any of the conditions of usage, which, as we know, have so great an influence upon the value of the insulation resistance ; others prefer to specify the nature of the insulation, and of the mechanical protection ; others, again, do not even take as much trouble as this. . . . . The legend of the Tower of Babel gives only a vague idea of the confusion which exists upon this question, which yet is one of supreme importance to the electrical industries." Some day, perhaps, we shall have in this country a corporate body capable and willing to undertake the task of dealing with the problem here indicated.

ELECTRIC LIGHT FOR WIMBLEDON.—At a meeting of the Wimbledon Local Board on the 19th inst. a proposal to take steps to obtain a provisional order for electric lighting was unanimously adopted. A wealthy suburb such as Wimbledon undeniably affords a promising field for domestic lighting, and if proper advice is obtained we know no reason why the Local Board should not achieve a decided success. We hope, however, that they will not permit themselves to fall a prey to any specious offers to carry out the scheme "on the cheap." The proper course to pursue in a scheme of this magnitude is undoubtedly to obtain specifications and estimates from some consulting electrical engineer of acknowledged status, who should also undertake the responsibility of seeing the work properly carried out from beginning to end. The only other admissible alternative is to ask for specifications and estimates from a number of first-class firms. Wimbledon is fortunate in numbering amongst its inhabitants more than one electrician of the foremost rank, so that the Local Board need not go far to seek for competent advice. Mr. Chatterton, who proposed the motion, made some sensible observations as to the probable cost to the users. He pointed out that electric lighting was admittedly a luxury, but where they had a sufficient number of wealthy residents he had no doubt that people would be as willing to pay for this luxury as for others.

CENTRAL STATION LIGHTING AT LIVERPOOL.—A Liverpool correspondent writes :—"The Committee of the Liverpool Corporation have recently been in communication with the Liverpool Electric Supply Company with regard to an application for a license which the above company are making to the Board of Trade. The terms of the draft license so prepared were approved at a general meeting of the council on Wednesday. The terms of the license provided for the continuous supply of electricity in the chief business and residential portions of Liverpool, the supply to be measured by meter, and to be charged on a sliding scale, varying from 1s. per unit for consumers who do not use the light for more than 400 hours a year to a price approaching fourpence per unit when lights are used continuously all the year round. A consumer using his lamps 1,200 hours per annum would pay at the average rate of 8d. per unit. A special clause is inserted in the license by which the theatres and other public buildings are entitled to be supplied at a reduction of 33 per cent. from the above prices. The Liverpool Electric Supply Company have had a central station

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operation for the last four years, and have therefore some experience as to public supply. They have recently finished a second central supply station, and a third and larger station is now in course of construction. Messrs. Holmes and Vaudrey are the engineers of the company."

AN EXAMPLE TO BE FOLLOWED.—The Vienna Industrial Museum has recently started a testing establishment which should prove of great value to electrical trade in Austria. Its provisional table of charges is as follows:—

Dynamos, according to size and tests required	£1	10	0	to	£5	0	0
Glow lamps, efficiency on photometer	1	0	0	to	5	0	0
Glow lamps, candle-power only	1	0	0			—	
Arc lamps, efficiency	1	10	0	to	2	0	0
Arc lamps, candle-power only	1	10	0			—	
Measuring instruments	0	10	0	to	2	0	0
Arc lamp carbons	1	0	0			—	
Specific resistance tests	1	0	0			—	
Temperature coefficient tests	0	12	0			—	
General photometric investigations on various sources of light	0	6	0	to	2	0	0

If the results are to be published a further payment is to be made to the funds of the institute. Such an establishment ought to be a success, and no doubt the provisional list will be much extended before long. We do not often introduce political cries into these columns, but we do feel moved by this to inquire, "Why should London wait?" Surely we ought by this time to have a standard laboratory of our own, where authoritative and impartial tests would be carried out by competent men. The question is one which will no doubt receive the early attention of the Association of Electrical Engineers whenever that coming organisation blossoms into actual life.

ELECTRIC STREET RAILWAYS IN AMERICA AND ELSEWHERE. A New York paper gives a list of seventeen street lines now operated by electricity in the States. Of these no less than fifteen employ overhead conductors, and the remaining two are conduit systems. When we consider that the overhead system is absolutely out of the question in this country, and that as regards the public streets the conduit systems have yet to demonstrate their "permissivity," the difference between the rate of progress here and over the water is not so surprising. Battery systems do not come immediately into the same category, because with them it is no longer a question as to practicability but as to economy, and this must take time to decide. Meanwhile we learn with regret that the only battery system (except Elieson's) at present in regular operation—namely, Julien's—is not doing at all well at Brussels. The charging station seems, in the first place, to have been badly designed and ill equipped, and difficulties of a quite unnecessary character have arisen there. But a still more fatal mistake was made in the assumption that anybody's dynamo would do for a motor. That fallacy is now, we take it, on its last legs. M. Julien was lately in this country negotiating with a prominent firm who supply electric motors, and we have reason to believe that the Brussels line will shortly be re-stocked with an efficient plant. Returning to America, the same paper gives a further list of eighteen lines in course of construction or under contract, and no less than fifty-five new roads projected, the whole of which are to be worked electrically.

COAST DEFENCE BY ELECTRICITY.—Although the recent operations in the attack and defence of Langton Harbour were conducted under unusually stringent conditions as to secrecy, it is stated, apparently on good authority, that both the War Office and the Admiralty have been strongly impressed with the great value of the electric search light in such operations. Electricity lends its powerful aid both in attack and defence, and equally above and below the water level; and now that the authorities seem at last to have taken up the question of coast defences in something like an earnest spirit, there can be little doubt that a good many orders for arc light equipments will be forthcoming within the next twelve months. Dynamos and engines and quick-firing guns are less expensive to equip and to maintain than permanent fortifications; they are a good deal more mobile, and more easily procured than heavy artillery, and while it is of course essential that our naval yards and harbours should continue to be protected in the old-fashioned way, yet we may doubtless look forward to the period when without exception all points of our coast line where an invader might attempt to gain a foothold shall be at least within easy hail of the modern system of electrical defence. For this, however, skilled manipulation and familiarity with electrical apparatus is essential. In the Volunteer Coast Defence Brigade which is contemplated we have no doubt that many of our readers will bear an honourable part. We are not aware that it is at present within our power to render any direct assistance to the movement in these columns, but should occasion arise it is scarcely necessary to add that we shall be eager to avail ourselves of the opportunity.

AN IMPORTANT ELECTRIC LIGHTING COMBINATION.—Some months since the Thomson-Houston Electric Company commenced the installation of a number of incandescent electric lighting plants in various American towns, in which the distribution was effected by means of transformers. Upon this legal proceedings were instituted by the Westinghouse Electric Company, alleging infringement by the former company of the Gaulard-Gibbs patent, which is owned and controlled by the Westinghouse Company. It is now authoritatively announced that the suit has been withdrawn, and that an amicable arrangement has been entered into between the two companies, by which they will hereafter work in harmony and in close business relations. It is learned that by the terms of the agreement, the Thomson-Houston Company acknowledge the validity of the Gaulard-Gibbs patents relating to electrical distribution by alternating currents, and will hereafter work under a license from the Westinghouse Company. The Thomson-Houston Company acquire the right to install the Westinghouse system in the six New England States, and also in connection with the arc lighting plants which it has established in the principal towns and cities throughout the United States, some 200 or more in number, most of which are operated by local companies; while, on the other hand, the Westinghouse Company will install the Thomson-Houston arc system wherever a plant of that kind may be needed in connection with the Westinghouse stations. The joint product of the extensive manufacturing establishments of the Westinghouse Electric Company at Pittsburg and the Thomson-Houston Company at Lynn will amount to several thousand lamps per day, together with the necessary dynamos and transformers, and the present indications are that the facilities of both factories will be taxed to the utmost to supply the immediate future demands for the extension of electric lighting in the States.

INSTALLATION AT LLOYDS, BARNETTS AND BOSANQUETS BANK.—The new premises of this bank, at 72, Lombard-street, have been supplied with an installation of 270 incandescent lamps by Latimer Clark, Muirhead and Co., of Westminster. Motive power is obtained from a Crossley "Otto" gas engine of 14 horse-power nominal (or about 33 indicated horse-power),

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fixed upon a stone bed underneath which is placed 4in. of hair felt. Air spaces are left also all round, and no vibration is felt in adjoining premises. The exhaust is taken a considerable distance horizontally in iron pipes, and then rises vertically in an air shaft to summit of building about 60ft. high. Cooling water is drawn from water main, and hot water runs to waste. Provision is made for measuring the quantity of water used. On a recent occasion about 29 per cent. of the total heat of combustion of gas used was found in the cooling water. This engine drives a 14·4-unit Westminster dynamo at 1,200 revolutions. The machine is shunt wound, horizontal type, by Latimer Clark, Muirhead and Co., and is fitted with worm wheel adjustment for brushes, and with automatic arrangement for switching on charging current when the electromotive force at terminals attains the proper amount. A battery of 104 E.P.S. accumulators of the 31 L type is employed; these cells were manufactured by Elwell-Parker and Co, to a specification by Drake and Gorham. A Blackman air propeller, driven by a belt from the engine shaft, keeps the room cool, and carries off the fumes from the cells. At present the lighting extends only to the first three floors, but foundations have been laid and space provided for duplicating the engines and machines in readiness for lighting the upper floors. The switch-board contains some new features, and the main leads are arranged in nine distinct circuits, connecting various portions of the building, so that the whole or any part of the system is perfectly under the control of one man. An Ayrton and Perry's voltmeter and two ammeters are attached to the switch-board, and there is, in addition, a third small ammeter which enables the attendant to test either of the nine separate circuits at will. The installation is altogether an excellent specimen of its class. Messrs. Henry Lea and Thornbery, of Birmingham, were the consulting engineers to the bank.

TRANSFORMER PATENTS IN AMERICA.—A REMARKABLE CORRESPONDENCE.—The position of the Westinghouse Company, who claim the sole right to employ alternate current transformers "on a closed circuit" in the United States, has, no doubt, been somewhat strengthened by the recent recognition of their claims on the part of the Thomson-Houston Company. It is, however, to be feared that the question will not be settled without extending still further the long catalogue of electrical patent litigation. Meanwhile, we have to record what appears on the surface to be a decidedly praiseworthy attempt on the part of the United States Company to render as short and simple as possible the proceedings which they appear to think inevitable. From the singular correspondence now published by the *New York Electrician and Electrical Engineer* we compile the following condensed version. It will be understood that, although conveying the essence of the letters, we are not reproducing the language verbatim throughout:—

Letter I.—Solicitors of U. S. Co. to Solicitor W——st——e Co. Your clients insert advertisements making claims which our clients don't admit. Enclosed you will find a statement of what we are doing, what we intend to do, and how we do it. Now, then, what have you to say, gentlemen? "We don't want to fight, but by," &c., &c. We deem it proper to say that in case you do not bring a suit at present we shall feel at liberty to make use of this correspondence in any subsequent litigation against our clients on the patents referred to.

Letter II.—Solicitor No. 2 to Solicitor No. 1. Not quite made up our minds at the present moment, but rather think we shall go for you. The course adopted by your client in regard to this matter, and its abandonment of the system of electrical distribution which it has always heretofore used, in order to adopt the alternating system, which we have not only patented but actually created in this country, is hardly to be justified by the laboured and unusual notice which you have favoured us with.

Letter III.—W——st——e Co. to U. S. Co. Thanks for candid admission, though this does not of itself atone for your flagrant disregard of our rights. We should have thought your conduct more fair if you had written before you started the business, and not when, after a "secret and systematic preparation," you are already opposing us in the field. We shall make use of every lawful means at our command to vindicate our rights. In conclusion, we would ask you to contrast your behaviour in this matter with our own conduct in reference to your three-wire patent, when, without question, and at considerable expense and trouble, we changed several plants rather than have the appearance of infringing upon your rights.

Letter IV.—U. S. Co. to W——st——e Co. This is very cruel. We went out of our way to be polite and attentive, and now you positively threaten us. And it is quite a mistake on your part to suppose that we have admitted an infringement of your patent claims; we only admit an infringement of the claims in your *advertisements*. We don't admit that we have abandoned our previous system, because we have not done so, and don't mean to. And we don't admit that we have done anything "secret," though we confess to being highly "systematical" in our procedure. As to the G. G. system you speak of, we would not have anything to do with it at any price. Perhaps you are not aware that we have secured the patent rights in this country of a certain Paul Jablochkoff. If you will just come round we shall be delighted to show you exactly what we are doing, and may possibly surprise you not a little.

Letter V.—W——st——e Co. to U. S. Co. You have indeed surprised us very much. Now that we have had the pleasure of inspecting your apparatus we fully comprehend that your devices and arrangements are not of a character to cause us any serious uneasiness, at least until they have undergone radical change. So sorry to have made mistake of taking you seriously. Hoping, however, to hear from you again some day.—Yours respectfully, (Signed) G. W., JR.

This is really a very funny episode, but it is scarcely to be supposed that the matter will actually be allowed to end here. Meanwhile it is but just to recognise that the correspondence does both parties infinite credit.

THE ELECTRIC LIGHT AT THE ADELAIDE JUBILEE INTERNATIONAL EXHIBITION, 1887.—The following description of this installation appears in our contemporary the *Engineer*:—"The promoters of the Adelaide Exhibition having called for tenders for lighting the buildings, to which several electrical firms responded, a tender from the Australasian Electric Light, Power and Storage Company, of London and Sydney, was accepted, and a contract entered into with the above company for supplying 140 arc lamps and 210 incandescent lamps. Although not a very extensive installation when compared with some of those we are used to see on this side of the globe, it is by far the largest arc light installation that has up to the present time been attempted in Australasia. The motive power for driving all the electric light plant is supplied by Messrs. Robey and Co.'s steam engines, through their agents, Messrs. Harrold Brothers, of Adelaide, whose firm are also the sole agents in South Australia for the Australasian Electric Light, Power and Storage Company. The plant, which is located at the south-east corner of the machinery hall, covers an area of 80ft. by 60ft.; the space is neatly railed off, so as to permit of a thorough inspection, but at the same time keeping the onlookers at a safe distance from the numerous pulleys, belts, and dynamos. The electric plant comprises ten No. 7A Brush arc dynamos, each of 8,000 watts capacity; one No. 6 convertible Brush arc dynamo of 6,000 watts capacity.

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This machine can, by means of an ingenious switch, be made to give a current of 10 amperes and 600 volts, or 20 amperes and 300 volts, which makes it a very useful machine for charging accumulators when not employed for working arc lights. The incandescent plant comprises three C² Brush Victoria dynamos, each of 8,000 watts capacity; one Edison-Hopkinson dynamo of 7,800 watts; and one Edison dynamo of 5,000 watts. The dynamos are fixed in two parallel lines and secured to heavy baulks of Oregon timber, which are securely bolted to transverse sleepers buried in 3ft. of concrete. The dynamos are driven from a line of countershafting 70ft. in length by 4in. diameter, supported on substantial wooden trestles. To avoid the risk of a total failure of the light due to an accident to an engine or dynamo the shafting is cut into several sections, each section driven respectively by the following engines of Messrs. Robey and Co.'s manufacture, viz., one 16 horse-power nominal portable engine, one 20 horse-power nominal portable engine, one 20 horse-power nominal compound semi-fixed engine, fitted with automatic expansion gear, one 16 horse-power nominal semi-fixed engine, one 12 horse-power nominal semi-fixed engine, and one 30 horse-power nominal horizontal engine fitted with Prôell's automatic expansion gear. There are ten arc circuits, four having 13 Fyfe-Main lamps in each and six running 15 to 16 Brush lamps, each making a total of 145 arc lights. Each arc circuit is provided with a switch, which is used for closing the circuit when the dynamos are started. As there is, however, always some difficulty in breaking a high-tension arc circuit through an arc forming across the contact surface of the switch, the field-magnet coils of the Brush dynamo are each connected to a separate switch on the switch-board. This switch, upon being closed, short circuits the field-magnet coils of its particular machine, with the result that in a few seconds the dynamo ceases to generate any current. The main circuit switch can now be opened without, of course, any sparking. Each of the incandescent light circuits is controlled by a main switch, and is also provided with the usual safety cut-outs. Cardew voltmeters are connected to the circuits of each of the incandescent dynamos. Two of Ayrton and Perry's direct-reading spring voltmeters are provided, one registering from four to twenty amperes for the arc circuits, the other registering up to 200 amperes for the incandescent circuits. In all 141 arc lamps and 211 incandescent lamps are employed. There are also several arc and incandescent lamps supplied to some of the exhibitors, which brings the total up to 145 arc and 266 incandescent lights. About eight miles of cable have been used for running the various circuits, which have been arranged, as far as possible, so that no particular building is lighted entirely from one dynamo, so that in case of a break-down the place would not be plunged into total darkness."

THE NEW CABLE LINE BETWEEN PORTHCURNO AND ZANTE.—The Eastern Telegraph Company, which is always quietly and steadily advancing, have just completed a very important addition to their already extensive system by laying cables between Porthcurno, *viâ* Lisbon, Gibraltar and Malta, and Zante, the whole work having been carried out by the Telegraph Construction and Maintenance Company. The first section between Porthcurno and Lisbon was laid from the ss. "Scotia," between the 11th and the 21st July. The total length is 891·83 n. miles, and consists of five different types of cable—viz., first, the heavy shore ends, 180lb. to n.m. sheathed with 10 No. 00 gal. iron wire; secondly, heavy intermediate, 10 No. 2 G.I.W.; thirdly, a lighter type, consisting of 10 No. 6; fourthly, a still lighter type, with 12 No. 13 homo. iron; and lastly, the deep sea type, of 9 No. 13 homo. iron. The two heaviest types are served with jute yarns and Clark's compound, and all the others with Johnson and Phillips's patent tapes and compound. The line was laid from Porthcurno to Lisbon, and cut and buoyed about 15 miles from Lisbon and the shore ends laid out from shore to this point. The total length of deep sea was 665 miles. The greatest depth passed through was 2,700 fathoms, and the line passes well to the westward of existing cables. Through the careful selection of the route by the company's general manager and their engineers, Messrs. Clark, Forde and Taylor, it is laid in a more uniform depth than the cables previously put down between England and Portugal. The line from Lisbon to Gibraltar was commenced on the 22nd, and finished on the 27th of July. The total length is 337 n. miles, and consists of four types of cable similar to those of the last section described. The maximum depth passed over was about 1,000 fms., and the mean about 145 fms. The Gibraltar and Malta section was commenced on 27 h of September from the ss. "Scotia," and paid out to within about twenty miles of Malta, and the end buoyed. The "Scotia" then proceeded to Zante, and commenced on the 8th of October to lay in the direction of Malta, and buoyed the end about six miles from that place on the 10th October. The "Scotia" then went into Malta and laid out the shore ends, completing the Malta-Zante section on the 11th inst. The "Scotia" next laid the shore end of the Gibraltar-Malta section, completing this section on the 12th inst. The reason for thus leaving the Gibraltar-Malta section buoyed for some days was on account of there being cholera at Malta, which would, had the ship entered Malta Harbour, have rendered her liable to quarantine detention at Zante. The length of the Gibraltar-Malta cable is nearly 1,126 n. miles, consisting of five types, four of which are similar to those described, and one type sheathed with 12 No. 9 G.I.W. The length of the Malta-Zante section is 374 n. miles. The core of this section is composed of 130lb. of copper and 130lb. of G.P. to the n. mile, and the types, as regards the sheathing, are similar to those described. We have not given the lengths used of each particular type, but most of the heavy shore ends extend into about 20 fms., and the deep sea type commences in depths varying between 200 and 400 fms. The core of all sections between England and Malta consists of 200lbs. of copper and 180lbs. of gutta percha per knot, that of the cable between Malta and Zante consists of 130lbs. of copper and 130lbs. of G.P. The present practice is tending towards increasing the weight of copper relatively to that of the insulator, which gives higher speeds for a given cost of core. The insulation resistance of the various sections at the fifth minute after laying was as follows:—

	At Sea Temp. Megs. per N. Mile.	Reduced to 75° F. and Atmospheric Pressure. Megs. per N. Mile.
Porthcurno and Lisbon ...	12,618	618
Lisbon and Gibraltar	2,571	565
Gibraltar and Malta.....	5,714	—
Malta and Zante	6,893	—

The whole work has been carried out with great promptitude and success, the last expedition having been only away five weeks and the first only three weeks. Mr. Lucas was in charge on the part of the Construction Company and Mr. Forde on the part of the firm of Clark, Forde and Taylor, engineers to the Eastern Telegraph Company. The company have thus ensured another line between England and Malta and on to Zante, and only touching at one foreign port, viz., Lisbon, and the line has been worked through admirably direct from Porthcurno to Gibraltar.

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JEHL AND RUPP'S SYSTEM OF CONTINUOUS-CURRENT TRANSFORMERS.

The system of continuous-current conversion by Messrs. Jehl and Rupp, of Brünn, described below, possesses many instructive features, and also evinces a considerable amount of ingenuity.

The inventors start by considering the case of a simple iron ring wrapped with two distinct windings, as shown in Fig. 1, and the disposition of the field, as indicated by the dotted lines, and its ordinary inductive effects upon the secondary circuit are described. The want of magnetic continuity in a simple ring when excited from diametrically opposite points on the primary winding would, however, entirely cripple such an apparatus for use as a transformer, even though the necessary pulsations or alternations of current were obtained. This consideration has led to the adoption of a second revolving part in the apparatus, the introduction of which, as will be readily seen from the figures, renders the magnetic current as complete as that obtained in the ordinary dynamo. This part of the machine may consist of either of the following, viz. :—(1.) A second laminated iron ring supported on a spindle, and running either within or alongside the first (Fig. 2). (2.) A

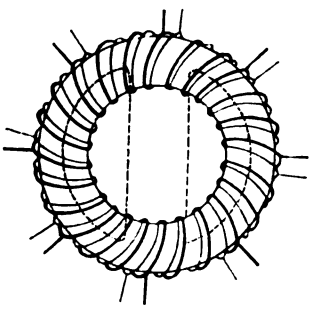

Fig. 1.

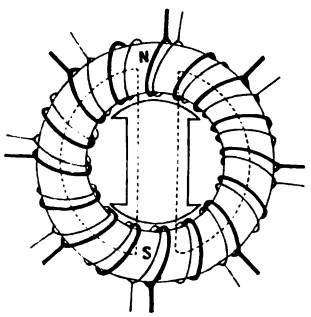

Fig. 4.

rotating drum in place of the ring (Fig. 3). (3.) A shuttle or H armature in place of the drum (Fig. 4). In each and all of the above arrangements it will be seen later that the revolving part corresponds to the field-magnets in an ordinary motor, and may be utilised to receive a part of the winding. It can, however, be also looked upon as a polarised armature, and for convenience it will here be termed the armature.

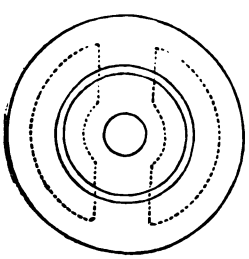

Fig. 2.

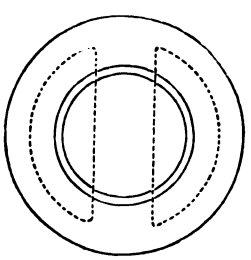

Fig. 3.

The object is now to send either a pulsating or alternating current through the primary and to collect the induced current from the secondary circuit. This is performed in the apparatus before us by means of what the inventors term a distribution commutator, half of which is illustrated in Fig. 5. Each point of access on both the secondary and primary circuits, indicated in the figure by the thick and fine lines respectively, is connected to a bar of the commutator, which for convenience in diagram is shown as if it were unrolled and laid flat upon the paper. These collecting bars are arranged in pairs, against each of which a separate brush makes momentary contact as the commutator revolves. Since these brushes are respectively connected with the several sections on the fixed ring the bars are arranged step fashion, as shown in the diagram, so that current is not taken from more than one diameter of the ring at any given time.

Two ordinary Gramme collectors are also fixed on the same spindle, one for each circuit, the bars of which are connected to the step bars aforesaid. A single pair of brushes press against each of these collectors, which respectively conduct the current to the primary circuit from the line and from the secondary to the lamp circuit. The whole commutator is on the same spindle with the armature, and is rotated with the latter at a uniform speed by some external source of mechanical power. It will thus be seen that by the action of the apparatus the fixed ring is successively polarised at diametrically opposite points, advancing in jerks by the angular distance corresponding to a section of the winding. A pulsating magnetic flux is thus generated in opposite directions through the fixed ring, the circuit being always completed by the armature, which is in synchronous motion with these pulsations. Under these circumstances an electric current of like pulsating character is generated in the secondary circuit, but which by means of the commuting arrangement above described, leaves the large brushes on the Gramme collector in the same state of continuity as the primary. A really clever device is adopted in the case of transformers connected in series, as follows :—Both rings, or the fixed ring and rotating drum, are wound with primary wire, there being no secondary winding at all. The secondary circuit is connected to the same points on the apparatus as the line wire from the central station—viz., to the large brushes on the Gramme collector. Since only one winding is used, a single commutator like that shown in Fig. 5 is sufficient, the step bars, with the Gramme collector bars, being connected to the different sections of the primary. Now, on rotating the commutator and armature, a counter E.M.F., due to the self-induction of the primary, will be set up, the current from which is taken off the large brushes and utilised in the lamp circuit. This E.M.F. will be constant, providing that the current in the primary is constant, and the plan is therefore only applicable when the transformers are used in series on a constant current circuit. It will be evident that the weak point in this device is the commutator with its numerous brushes, but we take it that this feature is susceptible of some practical improvement.

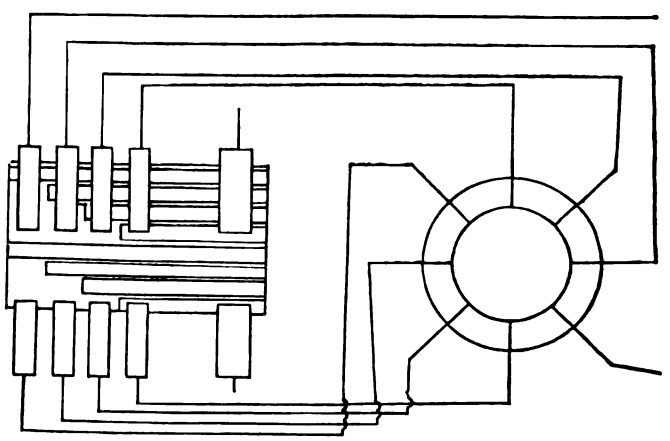

Fig. 5.

It is also suggested by the inventors that by suppressing the distribution commutator altogether, the apparatus may be employed as an alternating current transformer, but it needs little further examination to disclose the fact that this design cannot compare favourably, in point of economy, at any rate, with other transformers already in the market.

AN ELECTRO-THERMAL RECORDING TELEPHONE.

Since the time when Mr. W. H. Preece experimented with a diaphragm attached by its centre to a fine stretched wire of platinum, the possibility of reproducing speech by means of the thermal effects of a variable current in altering the tension of a fine wire has been placed beyond dispute. The instruments which we are about to describe are, however, we believe, the first illustrations of an attempt to turn this possibility to good account. Mr. Preece was, moreover,

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content to employ an ordinary carbon transmitter for his researches, but Mr. W. E. Irish (of Cleveland, Ohio) has attacked the problem at both ends, and produced a thermal transmitter as well as a thermal receiver. It is true, once more, that a transmitter depending upon the variation of temperature, primarily due to sound waves, is not in itself entirely novel, inasmuch as Prof. Forbes has described an instrument based upon this principle. But the Irish transmitter is totally different from that of Prof. Forbes, and above and beyond all it is capable of permanently recording, and at any time reproducing articulate speech after the manner of the phonograph. Whether or not the apparatus is adapted for industrial employment, we are sure that our readers will not fail to arrive at the conclusion that it constitutes a triumph of inventive ingenuity and constructive skill.

As regards the transmitter the principle adopted by Mr. Irish is the following. A pointed loop of platinum wire is maintained at a red heat by a local battery. This rests against an insulating roller, from which, however, it is separated by a varnished strip of tin foil. The back end of the loop rests against the transmitting diaphragm, and is thus brought into more or less intimate contact with the tin foil. The foil itself travels over rollers, and the pressure of the red hot platinum burns larger and smaller holes upon the varnish. The transmitting strip thus prepared passes between two metallic rollers which are connected with the line and earth respectively.

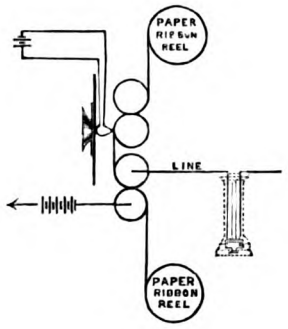

FIG. 1.

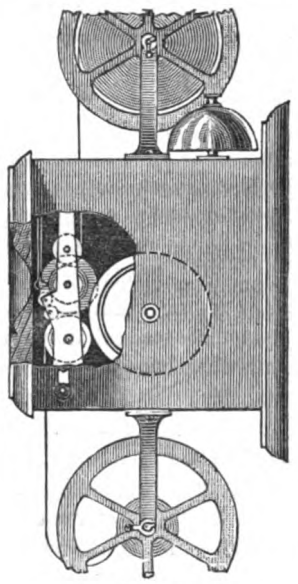

FIG. 2.

The following more detailed description is from the New York *Electrical World* :—

In the centre, at the back of an adjustable diaphragm, rests a wedge-shaped piece of platinum wire supported by two springs and resting with the thick end of the wedge against the centre of the diaphragm, while the point is directed inwards and lightly touches the ribbon in which the message is to be perforated. The ribbon behind the point passes over a drum which is recessed circumferentially in its centre, so as to offer no obstruction to the passage through the ribbon of the heated platinum point. This platinum point perforates the ribbon more or less according to its degree of heat, its shape and size, and the intensity of sound actuating the diaphragm. The louder or higher the pitch of the sound the deeper will be the penetration of the platinum point through the ribbon, and the larger in proportion will be the perforations. The perforated ribbon as it leaves the recessed drum is drawn between two other drums connected respectively to the line and one pole of the battery employed for transmitting ; the other pole being to ground, as shown in Fig. 1. The transmitting or last two mentioned drums are encircled by an elastic non-conducting material, made adhesive on the outer surface so as to hold the carbon powder with which they are served. Fig. 2 is a side elevation of the actual instrument.

The inventor has also employed with advantage, in lieu of the elastic covered carbon rollers, a vessel or funnel containing carbon granules. This funnel takes the place of the uppermost roller, and a flat conducting plate ,supported below the orifice in the bottom of the funnel, serves the purpose of a second roller, space being left sufficient to allow the perforated ribbon to travel freely between them. When the ribbon is drawn between the funnel and plate the carbon granules fall from the funnel into the perforations and make contact with the bottom plate.

It will be understood from the above that as the perforations in the insulated ribbon vary in size, in the same proportion will more or less carbon fall into them and the resistance of the circuit be varied. The larger the perforation the greater the space which will be occupied by the granules and the lower the resistance of the circuit ; and, as must necessarily follow, the smaller the perforations the less the space for the granules and the greater the resistance of the circuit. Mr. Irish, however, prefers the two elastic conducting drums, as illustrated, instead of the funnel and carbon granules for transmitting.

These drums make contact with each other through the perforations only, and so vary the resistance of the circuit accordingly. The interruptions and variations in the resistance of the circuit caused by the passage of the perforated ribbon between these contacts are made to reproduce on a receiving instrument at the distant end of the line the same sounds which actuated the diaphragm and perforated the ribbon at the transmitting end. The system permits of the making of a permanent record of all messages transmitted, and in such a manner that the messages may at any time thereafter be again transmitted by simply passing the ribbon between the contacts, or for local re-articulation or reproduction between the cold platinum point and its recessed drum. In either case the perforated ribbon is drawn between the contacts, or between the platinum point and recessed drum by the clockwork, as when used while speaking, the ribbon being first wound back off the lower on to the upper reel. When the message to be reproduced is on a filed ribbon, the ribbon is placed in the upper reel and wound off on an empty one placed below. Thus these instruments act as transmitters and reproducers of all messages previously sent on them. It will be seen that a local circuit is employed for heating the platinum while transmitting, but not for the receiving or reproduction or retransmission of a message.

The receiver most generally used in connection with this transmitter consists of a tube with an enlarged end for the diaphragm and an ear piece outwardly like an ordinary telephone receiver ; but here the similarity ends. A wire is stretched several times between the bottom of the receiver case and the diaphragm, each wire when doubled back being insulated from the next in such a manner as to cause the currents to travel each bend and the whole length of wire. The two ends of this wire are connected as usual to binding posts, to which also the line and ground wires are connected. The variations in the resistance and the interruption of the circuit caused by the difference of size or degree of the perforations, or their absence, cause the wire stretched in the receiver tube to expand and contract, correspondingly vibrating the diaphragm and reproducing the sounds given out at the distant end of the line. In this system of telephony the permanent and electro-magnets usually employed can be dispensed with, as well as carbon transmitters with diaphragms and tension regulators.

The transmitting part of this apparatus, according to the inventor, can be employed and gives excellent results as a phonograph. For this purpose it is found advantageous to use a somewhat stiffer stylus than the platinum one referred to for perforating the ribbon. The ribbon employed may be of especially prepared paper or metal foil well insulated.

The instrument described makes sound vibrations visible and produces a permanent record of them which can be stereotyped and printed from. It not only makes speech visible, but it is said to reproduce it in such quality of tone and clearness that persons acquainted with the speakers can recognise them by their voice.

INDEXES TO UNITED STATES PATENTS ON ELECTRICITY.—The United States Patent Office announces that Appendix No. 2 to the index to patents relating to electricity, covering the period of time from July 1, 1882, to June 30, 1883, has been issued, and is now for sale. These indexes, arranged alphabetically, numerically, and by classes, are completed to June 30th, 1883, and comprise the following volumes : — Vol. 1. Index to patents relating to electricity granted by the United States prior to June 30, 1881, with an appendix, July 1, 1881, to June 30, 1882. One volume, 250 pages. In paper covers, $3 ; bound, $5. Vol. 2. Appendix No. 2, July 1, 1882, to June 30, 1883. One volume, 50 pages. In paper covers, $1.50. Vol 3. Appendix No. 3, July 1, 1883, to June 30, 1884. One volume, 60 pages. In paper covers, $1.50. Vol. 4. Appendix No. 4, July 1, 1884, to June 30, 1885. One volume, 60 pages. In paper covers, $1.50.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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NOTICE.

We beg to notify that all correspondence and contributions intended for this Journal should be in future addressed to THE ELECTRICIAN, 1, Salisbury-court, Fleet-street, E.C., instead of to Mr. C. H. W. Biggs, whose connection with it has ceased. We deem it right to add that no other change whatever has occurred or is contemplated in the proprietorship or management of this Journal.

UNDERGROUND WIRES IN AMERICA.

The hasty and peremptory action of some of the American municipalities in ordering the removal of overhead telegraph and telephone wires has not resulted very satisfactorily to any of the parties concerned. In this country, where the authorities have been far more lenient to the telephone companies—and, it may be added, the companies a little less defiant of the public—a long-threatened crusade against this aerial nuisance is still indefinitely postponed. Meanwhile the companies proceed with their work, asserting their legal rights wherever they are challenged, but generally with a due sense of their insecurity. That sooner or later these overhead wires will have to go underground, at all events in populous towns, there can be little doubt. But the respite they at present enjoy will perhaps prove advantageous if only for the warnings we may derive from American experience in the art of laying wires underground. We say warnings, for after perusal of the three or four papers on this subject from American sources reproduced in these columns to-day, our readers will see that there is not much to learn in that quarter, though there is a great deal to avoid. On this point we are inclined to agree with our New York contemporary and namesake in saying, that if the work of providing that city with a system of electric conductors be left in the hands of the present Board of Electrical Control—which is the Subway Commission under a different name—and under their control, the last state of New York, electrically speaking, will be worse than the first. Of the several conduit systems approved by the Board some few, says the New York *Electrician*, may prove serviceable for a long time; but all the work so far can only be regarded as tentative. Certain essential elements of the problem seem to have been scarcely considered at all, and there is no evidence of a well-planned scheme such as ought to have been in existence before the work was commenced.

These remarks of our contemporary are borne out by Mr. W. E. SARGENT'S paper on the underground telephone wires at Brooklyn, consisting of nineteen miles of cables. First of all, there was the difficulty of obtaining the sanction of the local authorities for the construction of the underground conduits; for, although the companies were forbidden to fly their wires overhead, no provision was made to afford them a decent burying place underground. This obstacle, however, at length being overcome, various patterns of conduits and troughs and cables had to be tried experimentally, and, we need hardly add, expensively. Nothing very definite has yet been arrived at; but, on the whole, the officers of the Brooklyn Telephone Exchange are inclined to the opinion that a conduit of creosoted wood, though neither air nor water-tight, is superior to the asphalte or concrete type of conduit—at all events, as made and laid in America. For our own part, however, we are still inclined to think that this conclusion would have to be modified if the wooden conduit be compared with a properly designed and carefully constructed conduit of the bituminous or possibly of the concrete type. The American conduits seem invariably to be laid down with such frantic haste that any system which requires careful workmanship seldom or never gets a fair chance. This, at least, is the impression we derive not only from Mr. SARGENT'S paper, but also from other sources of information. The iron pipe system, which gives such excellent results in the service of the Post Office in this country, does not seem to be much employed in America, though it is in use, amongst other places, at Chicago and at Boston. The cables laid in creosoted-wood conduits are nearly all lead-covered, and the greater durability of the alloy of lead and tin (the proportion of tin being very small) continues to be manifest.

In Chicago the results are not more encouraging than in Brooklyn, though they are somewhat different in character. We have tried our best to master Mr. E. B. SUNNY'S methods, but so much is taken for granted, and so much described in language which none but a native American can understand, that any opinion we may venture to form must be offered with extreme reserve. Evidently the workmen are ignorant of the elementary principles of laying subterranean wires; but the results are rather to Mr. SUNNY'S liking. The joints leak, and half a pint of water can be poured out of some of the "sleeves"; but the speaking seems to be rather the better for these eccentricities. Only when there is plenty of moisture about does the "cross talking" disappear, a continuance of dry, warm weather being almost fatal to the communication, which is then only carried on "by frequent repetitions and considerable discomfort." The nine cables concerning which this opinion is pronounced are said to be "new and in good condition." It does not surprise us, therefore, to be told immediately afterwards that there is a "fallacy in requiring manufacturers to furnish a cable of 300 to 800 megohms per mile," seeing that this degree of insulation cannot be maintained even if desired, and is not desirable, even if practicable,

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because "cross talk is greater on a cable with a 'fancy' insulation than in one of a megohm." What is the precise difference between a "fancy" and a "megohm" we are not told; but we are led to suppose that both the writer and the subscribers to the Telephone Exchange at Chicago have a fancy for badly manufactured cables—a fancy which we should imagine they will have no difficulty in gratifying. Perhaps the incompetence of the workmen is not to be wondered at when the engineers talk in this fashion. A gleam of hope creeps in where it is said that a further "test indicates conclusively that we have used up all our margin, and that a slight addition to the length of the cables will make the connection of no commercial value." A still further test may possibly disclose the electrical "value" of the testing.

At Boston, according to Mr. DENVER, the Patterson system, which is the one also employed at Chicago, has given excellent results, perhaps for the same excellent reasons. According to English ideas the construction of the conduits and the enclosure of the cables are very roughly done. But that is probably no fault of Mr. PATTERSON or his system. We naturally turn, however, to his own remarks on "Joining Lead-Covered Cables." The whole process strikes us as calculated to make a British lineman's hair stand on end—always, supposing, as we said before, that we rightly interpret the language:—"The best way to make a splice is to strip the wires for an inch and a-half, bring them together, and, instead of making a long splice, bend them up, and then twist the ends together," leaving the joint at "right angles" to the conductor. What follows is equally startling, and may perhaps account for those curious tests to which we have adverted, and which lend some colour to the verdict of the New York technical journals that their underground electrical system has hardly yet passed the experimental stage. On the whole, we may congratulate ourselves that matters have not been pushed to a crisis with such precipitancy in this country. We agree with our American contemporaries that where numerous conductors of various kinds and sizes and for different purposes have to be provided for, some form of tunnel, large enough to admit of the wires and cables being hung in such a way as to be accessible at all points, is desirable, at all events for the principal routes. But in any case the undertaking demands the most careful consideration beforehand, and should be carried out "under the control of those who take a long look ahead and are more anxious to achieve a great public work carefully and thoroughly than to satisfy an unreasonable public clamour for burying all wires at once."

PARIS AND SCOTT'S CONTINUOUS-CURRENT TRANSFORMER AT THE NEWCASTLE EXHIBITION.

The continuous-current transformer of Messrs. Paris and Scott, at the Newcastle Exhibition, is now employed in lighting the model dwelling, and receives the current from the engine room through 900 yards of No. 12 copper wire. As the number of lamps in the villa is considerably below the capacity of the transformer, 64 lamps, besides some resistance, have been also placed in the circuit. The transformer is a two-pole machine, and two sets of coils are wound on the armature, the commutator for the primary coils being at one end of the shaft, that for the secondary at the other end. The primary coils contain four times as many turns of wire as the secondary, but of rather less than one quarter of the sectional area, so that the resistance of the primary wire is twenty times that of the secondary, and under normal conditions of working nearly the same amount of energy is absorbed in each. The field-magnet coils form a shunt to the secondary circuit, and the primary current is not employed in exciting the field. This causes the machine to hesitate before starting, and sometimes to start in the wrong direction. To obviate this Messrs. Paris and Scott propose to place a few turns of the primary wire upon the field-magnets. This will secure prompt starting in the proper direction, but will not sensibly interfere with the behaviour of the machine when fairly at work. The two sets of brushes for the primary and secondary currents respectively being independent, they may be set at any angle. Suppose the primary brushes to be set so as to make the machine run at the best advantage as a motor, then it is clear that if the secondary brushes were turned so as to be at right angles to the primary brushes, a big current might be sent through the secondary coils and the field-magnet coils, also excited from some external source, without offering any resistance to the rotation of the armature, and without any E.M.F. being produced by the rotation between the brushes of the secondary coil. Without going so far as this we may turn the secondary brushes into such a position that with a small resistance in the secondary circuit the E.M.F. in that circuit may be small, but the current very large—in fact, much more than four times the current in the primary coils—and yet the primary current may be quite capable of driving the machine at a high speed. Of course the product of the primary current and the E.M.F. between primary terminals—that is, the watts *in*—must exceed the product of the secondary current and the E.M.F. between its terminals, or the watts *out*, by an amount equivalent to the heat generated in both the armature coils and in the field-magnet, and the work required to overcome the mechanical resistance to the motion; but this is quite consistent with the current in the secondary circuit very much exceeding four times that in the primary, provided the E.M.F. be correspondingly reduced. In a test of the efficiency of the machine which has just been made the current in the secondary circuit was exactly four times that in the primary, the one being 42 amperes, the other 10·5 amperes. A voltmeter was employed having a resistance of 2,336 ohms. This was connected directly to the secondary circuit, and registered 74 volts. To the primary circuit it was connected through a resistance of 7,008 ohms, so that the same indication of the voltmeter corresponded to four times as many volts. This enabled the two readings to be taken in nearly the same part of the scale, and any error in the instrument was made of little importance. The voltmeter thus arranged registered 86 volts, corresponding to an actual E.M.F. of 344 volts. This represents a *commercial* efficiency of 86 per cent., the ampere meter employed in measuring the secondary current being inserted in the external circuit so as not to measure the exciting current of the field-magnets. By exerting considerable pressure on the brushes by hand the mechanical friction was very much increased, and the primary current was increased by an ampere, while the secondary current showed no change.

It will probably be very easy to control the brushes of the primary or secondary circuit automatically so as to keep the E.M.F. in the secondary circuit constant, whatever variations may take place in the E.M.F. of the primary. By shifting the primary brushes it was found possible to raise the E.M.F. of the secondary circuit until it was exactly one quarter of that of the primary. When the E.M.F. of the secondary circuit was then raised the whole output of the machine was necessarily increased, as no change was made in the number of lamps; but this was effected at the expense of efficiency, for the current in the primary circuit was increased in a greater ratio. In fact, when the E.M.F. of the secondary was thus raised to a maximum a considerable amount of sparking took place at the primary brushes, and the best position of the brushes to avoid sparking was found to be that which made the current in the secondary just four times that in the primary, so that there were the same number of amperes turns in each circuit. In one experiment when the speed of the engine had been reduced so that the E.M.F. of the primary was only 304 volts the brushes were set back until the E.M.F. in the secondary circuit was 76 volts. The current in the secondary was then 38 amperes, that in the primary 12¼ amperes,

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showing an efficiency of only 78 per cent., instead of 86 per cent. as above. When the brushes were placed so that the E.M.F. in the secondary was 63, and that in the primary 272 volts, the currents were respectively 38 and 10·25 amperes, showing an efficiency of nearly 86 per cent. The highest efficiency obtained in any experiment was 87½ per cent., when the currents were respectively 42 and 10½ amperes, giving the same number of ampere turns in each circuit, and the volts were respectively 70 and 320 ; but this figure is probably a little in excess.

The high tension or primary coils on the armature have a resistance of 1·45 ohm, the low tension coils about ·07 ohm. The field-magnet coils forming a shunt to the secondary circuit have a resistance of 49·2 ohms. If we take the case mentioned above, where the currents were respectively 42 and 10½ amperes and the E.M.F. 74 and 344 volts, we have

Watts absorbed in primary	3,612
Watts obtained in secondary	3,108
Watts wasted in heating primary coils	160
Watts absorbed in field-magnet coils	111
Watts absorbed in heating secondary armature coils	132

Leaving a deficiency of only 110 watts for driving the machine. There is thus a loss of 4·4 per cent. in the primary armature coils, 3 per cent. in the field-magnet coils, and 3·66 per cent. in the secondary armature coils, while rather less than 3 per cent. of the energy received is employed in doing the mechanical work of driving the armature against friction. The current in the secondary armature coils is of course that in the outer circuit, together with the exciting current. It is clear, from the above figures, that there is practically no loss by Foucault currents.

It was found that when the secondary brushes were turned through a considerable angle a great amount of sparking was produced, so that measurements have not yet been made with the primary brushes in their best position to drive the machine as a motor, and the secondary brushes turned through an angle so as to considerably reduce the E.M.F. of the secondary current.

THE PROPOSED ASSOCIATION OF ELECTRICAL ENGINEERS.

In our next week's issue we hope to be able to indicate more precisely the preliminary steps which it may then be thought desirable to take in respect to the proposed Association of Electrical Engineers. Our readers will of course agree that this is a matter in which it is desirable to remember the proverb, *festina lente*. Meanwhile we may note that our contemporary, *Industries*, devoted last week the whole of its leader to the subject, giving the project a very warm support. The majority of our correspondents whose letters do not appear will understand that nothing but want of space compels their omission, and that the greater the number of individual expressions of opinion which reach our hands, the stronger is our position with regard to subsequent action. Next week we shall probably furnish a list of the names of those firms who have expressed their adhesion to the general idea of the scheme. Meanwhile we select the following letters for publication :—

SIR : I have read with much interest the correspondence which has appeared on the subject of the proposed formation of an industrial association, as I recognise the necessity for combined action in regard to various matters of common interest to electrical firms.

A review of the correspondence, however, shows that while there is a general unanimity as to the desirability of an association of some kind being formed, there appears to be some divergence of opinion as to the precise objects and scope of the proposed institution. For this reason I agree with the suggestion which has been made that an outline scheme should be formulated for discussion at a public meeting.

If the association is to be successful and to possess the confidence of all sections of the trade, it is important that the objects to be attained should be clearly defined, and that the views of all should be adequately and fairly considered. As the representatives of the technical press possess by far the best means of ascertaining the views of the trade, there would be many advantages in their undertaking the initial work of drawing up a draft constitution, and I hope they can be prevailed upon to do this.

For my own part I fail to see that the objects of the association can be very numerous, if, as seems to be generally granted, the province of the existing societies is not to be encroached upon. That there is important and pressing work for the association to do cannot be denied, and if only a few of the many points suggested by Mr. Rawson are to be energetically pursued the need for a representative body is apparent. But the association should confine itself to matters requiring united action, *e.g.*, completing the work, already commenced, of securing a satisfactory amendment of the Electric Lighting Act, &c., and should not, by attempting to do impossible things, interfere with the natural growth and development of the industry. Such complex matters as "the maintenance of prices at a fair level," which are determined by the economic conditions of supply and demand, cannot well be settled by a resolution of a council, and had better be left to the operation of fair and legitimate competition.—Yours, &c., E. GARCKE.

112, Belvedere-road, Lambeth, S.E.,
24th October, 1887.

SIR : The proposal to establish an Association of Electrical Engineers, referred to in your journal and two of your contemporaries, is one that commends itself to us if it can be carried out properly.

Such an association should deal almost exclusively with the practical and commercial bearings of electric lighting and heavy electrical engineering, and the council or committee of management should be, we think, almost entirely composed of those commercially engaged in these industries. This being secured, the conditions of membership of the association need not necessarily be very strict.

The association should, we think, take a line entirely independent of either of the societies now in existence. The Society of Telegraph-Engineers has attained a prestige in its particular line which is too great to allow of a new society being affiliated to it without the latter being dwarfed. The new society must not be started under the ægis or protection of the old one, but stand by itself where it can have room to grow freely. The very constitution of the Society of Telegraph-Engineers and the atmosphere which surrounds it unfit it for starting the new society as it should be. Dealing until lately with telegraphy exclusively, and the telegraphs being the property of the State or of monopolist companies, the questions that have arisen for discussion have been purely scientific and not commercial or legislative. With the invention of the telephone and the glow lamp an endeavour was made to widen the area of discussion, but only as regards the "subjects" and not the method of their treatment. That society could not be modified to fill the present need without doing violence to itself and weakening its usefulness in its own peculiar work.

As regards the Dynamicables, we, and we think a good many others, hardly consider the work of this society as *serious*. Postprandial talking rarely leads to any practical issue, unless the object be to get funds for a charitable institution.

We hope the movement will succeed, and shall be glad to render any help in the matter that may be in our power.—Yours, &c., PATERSON AND COOPER.

London, October 20, 1887.

DEAR SIR : I shall be glad to co-operate with you in your endeavour to establish an Association of Electrical Engineers. * * * .—I am, dear sir, yours faithfully,

Culcheth, Bowdon, Cheshire, CHARLES LEVER
18th Oct., 1887.

DEAR SIR : We shall have great pleasure in joining your proposed Association of Electrical Engineers. We wish you all possible success for the undertaking, which promises much

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good, not only to our particular branch of industry but also to the public at large. * * * .—Yours faithfully,

M. IMMISCH & Co.

London, N.W., Oct. 19th, 1887.

DEAR SIR: It is with great pleasure we observe how very favourably the proposal to establish an Association of Electrical Engineers is being received. We need hardly say how entremely glad we shall be to give it our support, and trust its formation will speedily be effected. * * * .—We are, yours faithfully,

KING, MENDHAM AND Co.

Narrow Wine-street, Bristol, October 22, 1887.

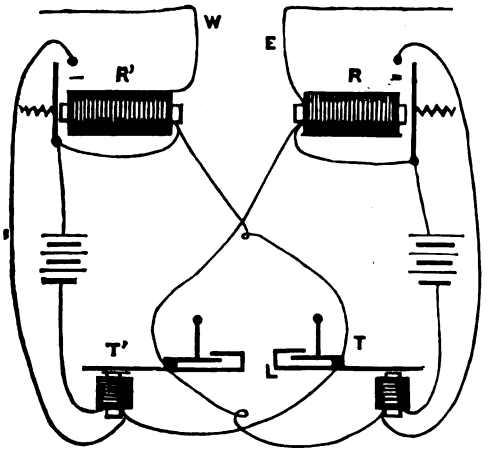
The following note from the *St. James's Gazette* is worth recording, as an illustration of the view likely to be taken of the movement by the outside public :—

An excellent suggestion, due to *The Electrician*, is being discussed with interest in the electric world. It is that there should be formed a new Association of Electrical Engineers, to include, not only that branch of the profession which already has a corporate existence in the Society of Telegraph-Engineers, but the whole of the electric light, motor, and other interests which have now reached so large a development. The arguments in favour of the proposal have been stated with much force by *The Electrician*; and, on behalf of the public outside the profession, we can only anticipate that such an association would do as much to raise electrical engineering with advantage to itself and to the public as has been done for their respective professions by the Institutes of Civil and Mechanical Engineers, the Iron and Steel Institute, and the Institute of Naval Architects.

A NEW REPEATER ARRANGEMENT.

The following note, by Mr. W. S. Cherley, appears in the New York *Electrical World* :—

"I have no doubt that most of your readers who are connected with the telegraph service have at some time experienced the annoyance incident upon unsatisfactory working of repeaters at intermediate repeater stations, probably caused by the lack of attention or the inability of the attendant to properly adjust them. In reflecting upon this matter I have devised a set of repeaters, using common instruments, which reduce the complication to a minimum.



New Repeater Arrangement.

"The action of the repeater, which consists of common relay and single transmitter, is as follows: East line opens, opening its transmitter T, which opens the west line. At the same instant the tongue of the transmitter makes contact with the lever, which closes the local circuit of the west transmitter T', so that the west relay cannot open it. Both relays R, R' work at the same time, but the local points of the west relay are cut out when the east transmitter is open. When the west line breaks the action is reversed. No extra local magnets or batteries are required. Half of the set can also be used for a single line on one side of a quadruplex."

CORRESPONDENCE.

RESISTANCE OF THE AIR SPACE IN DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Fricker in his last article on Dynamo Design (*The Electrician*, October 21st, p. 494) refers to a conversation Mr. Kapp and I had at Manchester about the resistance of the "air-space" in dynamos, in which I pointed out that commercial copper is often more or less paramagnetic, and, consequently, that the presence of copper (namely, the armature-wire) in the so-called air-space might account in part for a fact Mr. Kapp told me he had observed—that the magnetic resistance in actual machines was considerably less than the thickness of the air-space had led him to expect. But I gave no figures, having made no measurements of the magnetic permeability of commercial copper, and the 100 per cent. guessed at in the article is not mine.

Although the cause I suggested to Mr. Kapp may have some influence, it must not be forgotten that, as J. and E. Hopkinson have shown (*Phil. Trans.*, Part I., 1886, p. 333), the resistance of the air-space is lessened by the conduction of lines of force through neighbouring air—that is, round the edges (so to speak) of the plate of air that lies directly between the pole-piece face and the armature. The effect of this is virtually to widen the plate of air, giving it an effective area greater than that of the pole-piece face.—Yours, &c., J. A. EWING.

University College, Dundee, Oct. 22nd, 1887.

[In this connection we may add that Mr. Ravenshaw, of the firm of W. T. Goolden and Co., who has been remarkably successful in calculating the characteristics of new types of dynamos, informs us in a private letter that he always employs Prof. Forbes' lemmas in determining the air resistance.—ED. *E.*]

SPRINGS ON TELEGRAPH LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Caws has not realised the conditions that determine the stability of a telegraph wire. It has sometimes to resist the stress of a constantly applied force like the heavy broken branch of a tree or the continued pressure of a gale of wind against a tube of frozen snow, and when either of these stresses exceeds the breaking stress of the wire, no such contrivance as he has designed will be of any service whatever in preventing the wire from breaking. The stresses for which his regulator is devised do not interfere with telegraphs in the least. They are, in fact, imaginary troubles.

His tension regulator, which is by no means novel, would only magnify the evil, for it would cause more snow to accumulate.—Yours, &c., W. H. PREECE.

General Post Office, Oct. 26, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note in your last issue a description and sketch of a form of spring for telegraph wires patented, apparently, by Mr. Frank Caws.

Perhaps, as the subject is being further renewed since the British Association meeting, it would not be out of place, from an historical point of view, to mention that M. Bardonnaut, Directeur-Ingénieur of the French Postes et Télégraphes, in 1885 proposed a spring which would answer the same purpose, and which he calls a *sourdine*.

It was devised to be placed either between the wires and the insulator, as in Mr. Caws' system, or between the insulator pin and the telegraph post.

M. Bardonnaut appears to lay most stress on its qualities as a "deafener" to the humming noise due to vibration, rather than as a regulator to meet either any sudden forcible strain or the effects of the variation of temperature on the wires, which, I observe, is Mr. Caws' main object. The same springs would appear, however, to answer both requirements equally well. I have with me a description of M. Bardonnaut's proposed system. One of the vibrating springs he employs

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is of the same pattern as that which takes part in the adjustment of the synchronism in Prof. Hughes's type printing instrument, as being peculiarly well adapted for the purpose. M. Bardonnaut's plan shows no alternative course for the current to pass along besides the springs of necessarily high resistance, as is provided by the bow connection in Mr. Caws' method; in this respect, therefore, Mr. Caws' arrangement is certainly markedly its superior.

M. Bardonnaut states that his system was tried in Toulouse, with the result that householders, who had previously complained of the noise from the wires connected to their houses (to the extent of threatening to take legal proceedings), pronounced that since the alteration there was an entire absence of any similar disturbance.

It is not altogether improbable, I should fancy, that such an idea of springs for telegraph wires may have occurred to the minds of other telegraph engineers at various times since the evolution of electro-telegraphy, but for some good reasons presumably it has never yet, I believe, been carried into practice in this country; or else the advantages of such a plan are found to be insufficient to warrant the expense of construction entailed thereby.—Yours, &c.,

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ELECTRIC TRACTION.

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SIR: We have read with great pleasure your highly interesting article in last week's *Electrician* upon certain electrical experiments carried out on a section of the North Metropolitan Tramway by the Elieson Electric Locomotive Company. Congratulation is due to that company for the measure of success attained, but, judging from the figures published in your article, we cannot help feeling that greater success, from a commercial point of view, is still in store for electrical traction.

The first question naturally asked by tramway companies will be the amount of capital required to equip the lines with electrical traction. It is needless to point out the inconvenience of adding to the capital account of a very large proportion of existing tramway companies, where the present traffic receipts barely pay dividends; a difficulty which would be increased in proportion as the capital is enlarged. Therefore, in all arrangements for electrical traction, the primary consideration should be the reduction of the initial cost of equipment.

The next question asked will be the weight of the rolling load to carry a specified number of passengers, the reduction of which must be a serious consideration in electrical traction.

Question number three will be the comparison in length of car and electric locomotive with that of tramcar and horses, compactness being of the highest importance in crowded streets.

One other inquiry will be—what are we to do with our present rolling stock?

The Electrical Traction Syndicate, of which I have the honour to be secretary, in all their arrangements have had the solution of the above four questions as their chief object; so taking the statements contained in your article as my text, I will answer these questions.

(1.) *Initial Expenditure.*—At page 495 you say, "under this system of separate locomotives it is necessary to have two to each car," and "an initial expenditure of about £1,100 per car, as against only about £400 for horses, so that to put the two systems on an equal footing in this respect the depreciation must be at only one-third the rate in the former case." Now, the average life of tramcar horses cannot be taken at much more than three years. This means a depreciation of 33 per cent., and thus, to balance the greater initial expenditure with locomotives, this electrical system would require a depreciation of only 11 per cent. *Can this be possible?* The E. T. Syndicate, on the other hand, reduce this initial expenditure of £1,100 by nearly one half. Their self-contained cars, carrying the same number of passengers, cost only about £600, in comparison with two locomotives valued at £1,150 and the car which they haul, say, at £160—in all £1,310. In our case there is only one change of accumulators per day, the change requiring no longer than four minutes, and each set of accumulators gives half a day's run of thirty-five miles.

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Stabling.—As regards storage room for locomotives, it is obvious that three times the space will be required where a car and two locomotives have to be put up instead of one self-contained car only.

Time Saved at Termini.—With locomotives time is lost by uncoupling, shunting, and re-coupling before starting, whereas with our cars we run in, and can instantly reverse for the return without a moment's loss of time.

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Malden-crescent, Kentish Town, London, N.W.,
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ON ELECTRIC STREET CARS, WITH SPECIAL REFERENCE TO METHODS OF GEARING.*

BY A. RECKENZAUN, C.E.

(Continued from page 502.)

GRADIENTS.

The effect of gradients is a matter of simple calculation, and it must be provided for in designing and constructing a motor. We have calculated above that the minimum effective power for a six-ton car running at six miles an hour on the level is nearly two-horse power, exclusive of gear friction or any other waste. If we have to overcome a gradient of 1 per cent., for instance, the resistance due to gravity will be 22·4 pounds for each ton, or 134·4 pounds for the loaded car. Therefore we shall require about 4 horse-power to pull this car up a grade of

* Paper read before the American Institute of Electrical Engineers, New York, Sept. 20th, 1887.

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PROF. FORBES' TABLES FOR CALCULATING THE SIZE OF CONDUCTORS.

TABLE (A).

Cost per horse-power per annum.	Section in Square Centimetres per 100 Amperes.																				Cost per horse-power per annum.
	·4	·6	·8	1·0	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·2	2 4	2·6	2·8	3·0	3·5	4·0	
20	30·	13·	7·5	4·8																		20
40	60·	27·	15·	9·6	7·9	6 6	5·7	4·9														40
60	90·	40·	22·	14·	12·	10·	8·5	7·3	6·4	5·6	5·0											60
80		53·	30·	19·	16·	13·	11·	9 8	8 5	7·5	6·6	5·9	5·3	4·8								80
100		67·	37·	24·	20·	17·	14·	12·	11·	9 4	8·3	7·4	6·6	6·0	4·9							100
120		80·	45·	29·	24·	20·	17·	15·	13·	11·	9·9	8·9	7 9	7·2	5 9	5·0						120
140		93·	52·	34·	28·	23·	20·	17·	15·	13·	12·	10·	9·1	8·4	6·9	5·8	5·0					140
160			6C·	38·	32·	27·	23·	20·	17·	15·	13·	12·	11·	9·6	7·9	6·6	5·7	4·9				160
180			67·	43·	36·	30·	26·	22·	19·	17·	15·	13·	12·	11·	8·9	7·5	6·4	5·5	4 8			180
200			75·	48·	40·	33·	28·	24·	21·	19·	17·	15·	13·	12·	9·9	8·3	7 1	6·1	5·3			200
250			93·	60·	49·	42·	35·	31·	27·	23·	21·	19·	17·	15·	12·	10·	8·8	7·6	6 6	5·0		250
300				72·	59·	50·	42·	37·	32·	28·	25·	22·	20·	18·	15·	13·	11·	9·2	8·0	5·9		300
350				84·	69·	58·	49·	43·	37·	32·	29·	26·	23·	21·	17·	15·	12·	11·	9·1	6·8	5·2	350
400				96·	79·	66·	57·	49·	42·	37·	33·	30·	26·	24·	20·	17·	14·	12·	11·	7·8	6·0	400
450					89·	75·	64·	55·	48·	42·	37·	33·	30·	27·	22·	19·	16·	14·	12·	8·8	6·9	450
500					99·	83·	71·	61·	53·	47·	41·	37·	33·	30·	25·	21·	18·	15·	13·	9·8	7·7	500

N.B.—The cost per horse-power per annum must be taken in the same units as the cost of conductor in Table (B). Shillings, francs, marks, or quarter-dollars are most convenient.

TABLE (B).

Rate of Interest.	Cost per Additional Kilogramme of Copper.																		Rate of Interest.
	1·2	1·3	1 4	1·5	1·6	1·7	1·8	1·9	2·0	2·5	3·0	3·5	4·0	5 0	6·0	7·0	8 0		
5	5·3	5·8	6·2	6·7	7·1	7·5	8·0	8·4	8·9	11	13	16	18	22	27	31	36	5	
7½	8 0	8·7	9·3	10	11	11	12	13	13	17	20	23	27	33	40	47	53	7½	
10	11	12	12	13	14	15	16	17	18	22	27	31	36	44	53	62	71	10	
12½	13	14	16	17	18	19	20	21	22	28	33	39	44	56	67	78	89	12½	
15	16	17	19	20	21	23	24	25	27	33	40	47	53	67	80	93	—	15	

N.B.—Cost of conductor must be taken in the same units as the cost per horse-power per annum in Table (A); shillings, francs, marks, or quarter-dollars are most convenient.

N.B.—If the cost of conductor is given in pounds sterling per ton, divide this number by 50 to obtain the results in shillings per kilogramme.

Example.—Conductor costs 2·0 francs per additional kilogramme of copper. Rate of interest is 10 per cent. The auxiliary number found from these numbers in Table (B) is 18. If a horse-power costs 250 francs per annum, looking along this row in Table (A), the auxiliary number 18 is between 1·8 and 1·9 square centimetres per 100 amperes.

1 in 100. With a 2 per cent. grade we must have about three times the power used on level roads, and, roughly speaking, each per cent. of grade involves as much energy as the propulsion of a given weight over a horizontal road, if the speed is to be kept constant. On steep grades, however, it is customary to run a little slower, whereby some of the energy is saved; but for a car of the above weight, if it has to overcome grades of 4 per cent., it will not be safe to have less than eight horse-power available upon the driving axles. In addition to this the motor has to supply the power which is unavoidably wasted in the gearing used for transmitting motion from the armature shaft to the car axle. An ordinary street car wheel of 30in. diameter has to revolve at least 77 times in the minute, in order to traverse a distance of seven miles an hour. Up to the present time no one has succeeded in constructing an electric motor of reasonable dimensions, weight, and efficiency to work at such a low speed. Most of the existing motors revolve at from six to twelve times the above velocity ratio, therefore it became necessary to introduce speed-reducing appliances between the motor and the driving axles.

GEARING

The problem of devising suitable gearing for street cars carrying their own motor has been and is still one of the greatest importance, and I propose now to offer a few remarks with reference to this subject by citing some examples which came under my own observations. The conditions to be satisfied are by no means simple, and it is somewhat difficult to arrange them in their order of merit. Most engineers endeavour to retain the recognised dimensions of street cars, because great deviations therefrom involve many inconveniences, and it is wise to adhere as much as possible to the rules which have been established by custom, convenience and general utility. The fact that most of the street cars in all parts of the world are similar in shape indicates forcibly that a particular pattern satisfies the demand. When taking that popular pattern of car and adapting it to our electrical and mechanical apparatus, we find that the space at our disposal underneath the floor and between the axles is meagre and extremely limited. Within this small compass we have to fix the gearing which has to give the highest possible return of a given power: it has to be strong, durable, yet light in weight; noise and vibration have to be carefully avoided; the mechanism must be simple, certain in its action, protected from wet and dirt, and, finally, of reasonable cost. How to combine all these virtues has been the study of every engineer who has made electrical traction his serious study.

STEEL SPIRAL CORDS.

In regard to my own observations, one of the prettiest kinds of gearing in actual use is that on one of the cars of the Berlin Lichterfeld Electric Tramway, which was constructed six and a-half years ago by Messrs. Siemens and Halske. This car has a capacity for 24 passengers; it weighs when empty 3·2 tons, and makes a speed of 12 miles an hour. The electric motor is fastened under the floor in the centre of the car, having its shaft parallel to the axles. On the motor shaft is a small cast-iron pulley, which has 27 V-grooves on its rim, and within these grooves work an equal number of spiral wire cords, which transmit the motion to both axles of the four-wheeled car. The axles carry the large pulleys, one of which has 13 V-grooves on its circumference, and the other 14 grooves corresponding with those on the pulley on the motor

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Cost per horse-power per annum.	Section in Square Centimetres per 100 Amperes.																				Cost per horse-power per annum.
	·4	·6	·8	1·0	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·2	2 4	2·6	2·8	3·0	3·5	4·0	
20	30·	13·	7·5	4·8																		20
40	60·	27·	15·	9·6	7·9	6 6	5·7	4·9														40
60	90·	40·	22·	14·	12·	10·	8·5	7·3	6·4	5·6	5·0											60
80		53·	30·	19·	16·	13·	11·	9 8	8 5	7·5	6·6	5·9	5·3	4·8								80
100		67·	37·	24·	20·	17·	14·	12·	11·	9 4	8·3	7·4	6·6	6·0	4·9							100
120		80·	45·	29·	24·	20·	17·	15·	13·	11·	9·9	8·9	7 9	7·2	5 9	5·0						120
140		93·	52·	34·	28·	23·	20·	17·	15·	13·	12·	10·	9·1	8·4	6·9	5·8	5·0					140
160			6C·	38·	32·	27·	23·	20·	17·	15·	13·	12·	11·	9·6	7·9	6·6	5·7	4·9				160
180			67·	43·	36·	30·	26·	22·	19·	17·	15·	13·	12·	11·	8·9	7·5	6·4	5·5	4 8			180
200			75·	48·	40·	33·	28·	24·	21·	19·	17·	15·	13·	12·	9·9	8·3	7 1	6·1	5·3			200
250			93·	60·	49·	42·	35·	31·	27·	23·	21·	19·	17·	15·	12·	10·	8·8	7·6	6 6	5·0		250
300				72·	59·	50·	42·	37·	32·	28·	25·	22·	20·	18·	15·	13·	11·	9·2	8·0	5·9		300
350				84·	69·	58·	49·	43·	37·	32·	29·	26·	23·	21·	17·	15·	12·	11·	9·1	6·8	5·2	350
400				96·	79·	66·	57·	49·	42·	37·	33·	30·	26·	24·	20·	17·	14·	12·	11·	7·8	6·0	400
450					89·	75·	64·	55·	48·	42·	37·	33·	30·	27·	22·	19·	16·	14·	12·	8·8	6·9	450
500					99·	83·	71·	61·	53·	47·	41·	37·	33·	30·	25·	21·	18·	15·	13·	9·8	7·7	500

N.B.—The cost per horse-power per annum must be taken in the same units as the cost of conductor in Table (B). Shillings, francs, marks, or quarter-dollars are most convenient.

TABLE (B).

Rate of Interest.	Cost per Additional Kilogramme of Copper.																	Rate of Interest.
	1·2	1·3	1 4	1·5	1·6	1·7	1·8	1·9	2·0	2·5	3·0	3·5	4·0	5 0	6·0	7·0	8 0	
5	5·3	5·8	6·2	6·7	7·1	7·5	8·0	8 4	8·9	11	13	16	18	22	27	31	36	5
7½	8 0	8·7	9·3	10	11	11	12	13	13	17	20	23	27	33	40	47	53	7½
10	11	12	12	13	14	15	16	17	18	22	27	31	36	44	53	62	71	10
12½	13	14	16	17	18	19	20	21	22	28	33	39	44	56	67	78	89	12½
15	16	17	19	20	21	23	24	25	27	33	40	47	53	67	80	93	—	15

N.B.—Cost of conductor must be taken in the same units as the cost per horse-power per annum in Table (A); shillings, francs, marks, or quarter dollars are most convenient.

N.B.—If the cost of conductor is given in pounds sterling per ton, divide this number by 50 to obtain the results in shillings per kilogramme.

Example.—Conductor costs 2·0 francs per additional kilogramme of copper. Rate of interest is 10 per cent. The auxiliary number found from these numbers in Table (B) is 18. If a horse-power costs 250 francs per annum, looking along this row in Table (A), the auxiliary number 18 is between 1·8 and 1·9 square centimetres per 100 amperes.

1 in 100. With a 2 per cent. grade we must have about three times the power used on level roads, and, roughly speaking, each per cent. of grade involves as much energy as the propulsion of a given weight over a horizontal road, if the speed is to be kept constant. On steep grades, however, it is customary to run a little slower, whereby some of the energy is saved; but for a car of the above weight, if it has to overcome grades of 4 per cent., it will not be safe to have less than eight horse-power available upon the driving axles. In addition to this the motor has to supply the power which is unavoidably wasted in the gearing used for transmitting motion from the armature shaft to the car axle. An ordinary street car wheel of 30in. diameter has to revolve at least 77 times in the minute, in order to traverse a distance of seven miles an hour. Up to the present time no one has succeeded in constructing an electric motor of reasonable dimensions, weight, and efficiency to work at such a low speed. Most of the existing motors revolve at from six to twelve times the above velocity ratio, therefore it became necessary to introduce speed-reducing appliances between the motor and the driving axles.

GEARING

The problem of devising suitable gearing for street cars carrying their own motor has been and is still one of the greatest importance, and I propose now to offer a few remarks with reference to this subject by citing some examples which came under my own observations. The conditions to be satisfied are by no means simple, and it is somewhat difficult to arrange them in their order of merit. Most engineers endeavour to retain the recognised dimensions of street cars, because great deviations therefrom involve many inconveniences, and it is wise to adhere as much as possible to the rules which have been established by custom, convenience and general utility. The fact that most of the street cars in all parts of the world are similar in shape indicates forcibly that a particular pattern satisfies the demand. When taking that popular pattern of car and adapting it to our electrical and mechanical apparatus, we find that the space at our disposal underneath the floor and between the axles is meagre and extremely limited. Within this small compass we have to fix the gearing which has to give the highest possible return of a given power: it has to be strong, durable, yet light in weight; noise and vibration have to be carefully avoided; the mechanism must be simple, certain in its action, protected from wet and dirt, and, finally, of reasonable cost. How to combine all these virtues has been the study of every engineer who has made electrical traction his serious study.

STEEL SPIRAL CORDS.

In regard to my own observations, one of the prettiest kinds of gearing in actual use is that on one of the cars of the Berlin Lichterfeld Electric Tramway, which was constructed six and a-half years ago by Messrs. Siemens and Halske. This car has a capacity for 24 passengers; it weighs when empty 3·2 tons, and makes a speed of 12 miles an hour. The electric motor is fastened under the floor in the centre of the car, having its shaft parallel to the axles. On the motor shaft is a small cast-iron pulley, which has 27 V-grooves on its rim, and within these grooves work an equal number of spiral wire cords, which transmit the motion to both axles of the four-wheeled car. The axles carry the large pulleys, one of which has 13 V-grooves on its circumference, and the other 14 grooves corresponding with those on the pulley on the motor

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shaft. The wheel base is five feet nine inches, consequently there is only a distance of two feet ten and a-half inches between the centres of the connected pulleys.

The cords are made of a pair of steel wires wound closely upon a mandrel of about $\frac{1}{8}$in. in diameter, and when this mandrel is withdrawn there remains a stiff, yet flexible spiral, whose external diameter is scarcely $\frac{7}{32}$ of an inch. When cut to the proper length these cords are stretched over the grooves and connected at the ends by means of steel eyes and a steel link. Experiments made with this gear showed that eight spiral cords suffice for transmitting the power to the axles when the car was full of passengers, and as there are actually twenty-seven cords the margin of safety was deemed more than sufficient. It is a pleasure to ride on this car; there is no noise or vibration, and I was told that the spirals last a long time if carefully adjusted; but this method of transmission is not sufficiently positive to warrant its application on steep grades. On this line there is no grade of over 1 per cent. rise.

CHAIN GEARING.

The second car on the Lichterfeld tramway, which, by the way, must be regarded as the oldest line in the world as far as continuous successful operation is concerned, has chain gearing. The motor shaft is provided with a small toothed wheel, and one of the axles carries a large wheel with teeth to correspond to the gaps in the pitch chain links. This mode of transmission causes some noise and vibration, and this car runs slower than the other with same amount of energy. This is accounted for by the greater friction on the surface of the teeth, as well as by the bending and unbending of the link joints; there is, besides, a constant probability of the comparatively heavy chain being thrown off tangentially by centrifugal force. But this kind of gearing furnishes an absolute or positive motion, which cannot be relied on by methods depending upon frictional adhesion alone.

Some four years ago I applied two pitch chains, four toothed wheels and countershaft for propelling a heavy storage battery car in London. The chains were of steel and substantially made; the wheels of phosphor-bronze correctly shaped. I found that the chain on the fast running, first-motion shaft, rattled considerably. This chain stretched a little, when the links began to ride upon the points of the teeth, and eventually broke the teeth of the small wheel on the armature shaft. Previous to that I employed some other gear, which will be mentioned shortly.

Mr. Trail, the manager of the Portrush electric railway in Ireland, has been more fortunate than I with chain gear, but he is not perfectly satisfied, and he is now experimenting with something else. Pitch chains are also used on the Besbrook-Newry electric railway and on the Ryde Pier cars. Mr. Holroyd Smith adopted this mode of transmission on the first cars at Blackpool, in England, but he has since changed it to worm gearing, with which he is better satisfied.

CONICAL DISCS AND CHAINS.

About five years ago I had the idea that it might be advantageous to vary the speed of a car mechanically without interfering with the motor or even the supply circuit. I took out a patent for this in 1882, and applied it to the propulsion of a large street car. The motor was carried by a frame supported upon the axles by bearings and springs, to counteract the effects of vibration. By this arrangement the whole apparatus was rendered independent of the car body, and it could be easily detached. The speed pulleys consisted of conical discs, which, when placed face to face on a shaft, each pair formed between them a grooved pulley, and by shifting these discs on the shaft towards or from each other the said groove could be made wider or narrower, as desired. Two pairs of discs on different shafts were connected by means of a chain, the links of which were surrounded by wedge-shaped pieces of leather. The cross-section of this chain band was thus shaped in order to fit into the V-grooves offered by the cones. When the said discs were pressed closely together, then the band assumed a position near the circumference of the discs, but when the latter were separated, then the groove widened, the band changed its position and ran on some portion of the conical surfaces nearer the centre of the pulley. Thus the effective or acting diameter of the first motion pulley was varied at will by pressure, and the cones on the second motion shaft followed suit automatically, because the length of the band was constant, and the second pair of cones was pressed together by a strong spring. This arrangement looked very nice, but its efficiency was low; there was a great waste of power through friction, and we finally abandoned it. It worked silently, it was strong, and took up little room. The band slipped often when the car was starting or mounting an incline.

STRAPS AND PULLEYS.

Mr. Volk, of Brighton, England, employs leather link belts with great success for transmitting the power of the motor to the car axle. This railway has been in operation since August, 1883. Mr. Volk tried first, single leather belts, but they broke every day or two; then he used double belts with little better results; and some three years ago he adopted the leather link belt, which has given entire satisfaction. I have seen one of the latter which has driven a car over 50,000 miles and it was not worn out then. These belts stretch when first put on; the bearings of the countershaft are therefore made adjustable by means of a slide whereby the slack may readily be taken up. When starting the car the belts slip a little, but this is not considered a disadvantage. There are no curves on the Brighton line, and I often wondered whether this method of gearing would satisfy the terrible pull on the very sharp curves which occur on some street railways.

Mr. Van Depoele has given a high testimony in favour of link belts of a special construction after using them for a considerable time, and running them at a great velocity. Like Mr. Volk, he attaches the motor to the car body in order to give it the benefit of the existing flexibility of the car springs. Mr. Van Depoele's link belts, I understand, are made of steel, with special bearing surfaces; they have been used on a line of his construction at Windsor, in Canada; at Scranton, Pa., he employs spur gearing.

SPUR GEARING.

There exists a variety of opinions on the subject of toothed wheels in connection with electric motors, and each opinion seems based upon actual experience. I have seen spur gearing used on electric cars in Europe and in this country, and I give you freely all I know about it. The first I saw was on the Moedling line, near Vienna, in Austria. The noise created there was not very great, but there was occasionally some trouble due to the untimely deterioration of the teeth. This was especially remarked by the manager of the Frankfort Electric Railway in Germany, which is constructed on precisely the same principles, with the difference that the former runs through a country district where there is much less traffic, and the rails are laid on the tops of transverse sleepers like a steam railroad; there is less dust and mud to contend with. Between Frankfort and Offenbach, on the other hand, the rails are laid through populated streets, whereby all the disadvantages of city traffic are brought into play. The gearing of the cars on this line is very noisy, and it wears out quickly. The train of wheels consists of a pinion on the motor shaft having 17 teeth, which gears into a spur wheel of 56 teeth keyed upon a countershaft. On this countershaft is a pinion of 26 teeth, and this drives a spur wheel of 52 teeth, fastened to the car axle. The velocity ratio, therefore, is as 1 to 6·6 between the motor spindle and the driven axle The armature makes about 550 revolutions when the car travels at the rate of seven and a half miles an hour. The pinions are made of hard gunmetal, and they wear out in about a month. I have seen a number of rejected pinions, the teeth of which were ground into the shape of a fine wedge. The spur wheels are of cast steel, and they last about ten months when in continuous service. I was surprised to see these; and what with the noise, the excessive weight and other drawbacks, it made me more than ever prejudiced against such a mode of mechanical transmission on street cars. My views on this point have, however, been somewhat modified since I have been in this country. I had the privilege of being

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invited to assist Mr. W. Wharton, jun., of Philadelphia, in fitting up an electric street car. There we used a set of spur gearing which was supplied by the Sprague Company. In this case the motor shaft, which runs at from 500 to 600 revolutions a minute, carries two steel pinions, one at each end of the shaft, and these pinions gear direct into two cast iron spur wheels upon the driving axle, without any intermediate wheels. The motor is partly suspended on the axle and partly on the body of the car. We have run several hundred miles with this car under all conditions of loads, gradients, and weather, on some of the roughest tracts in Philadelphia, but up to this moment not a single hitch has occurred. The gearing is practically noiseless, it is efficient and strong, and I see comparatively little indication of wear. The teeth are beautifully shaped, therefore somewhat expensive, but if they last long enough, and if they do not rattle when partially worn, this expense can be ignored. This car contains, besides its usual weight, about 3,200lb. of storage batteries; it has to mount grades of 5 per cent., and run on curves of 35ft. and even 25ft. radius, which means very hard work.

(To be concluded.)

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON STANDARDS OF LIGHT.

The committee has been anxious during the past year to carry out comparative experiments on the various standards of light hitherto proposed, but has been prevented by want of funds from doing much. Prof. W. G. Adams, however, has presented a report to the committee on preliminary experiments made by him, and the committee is fully convinced that if provided with funds they will be able during the next year to complete experiments which will lead to recommendations which, if adopted, would place the question of standards on a satisfactory footing.

ON SOME POINTS IN ELECTROLYSIS AND ELECTRO-CONVECTION.*

BY PROF. G. WIEDEMANN.

I must congratulate the British Association on the reports of the Committee on Electrolysis, and specially that Prof. Oliver Lodge has directed the course of its investigation, for it could not have been entrusted to abler hands.

Some time ago I read a very interesting report which Prof. Armstrong communicated at the last meeting of the British Association, and the hypotheses he has advanced on the subject of electrolysis. There is a great deal that is hypothetical in these things. Allow me, therefore, to give expression to some aphoristical suggestions about some points more accessible to observation which I think ought first to be discussed.

I. The first question is, What is an electrolyte? What compounds are electrolytes? What are the ions of the electrolytes? Now, one generally says that electrolytes are salts, that they are binary compounds. But what is a binary compound? It is a compound decomposed by a current into two different compounds or elements; and when you say that electrolytes are salts you may as well say salts are electrolytes. Therefore it is very difficult to give a definition, and, even if we assume the general though not clearly defined idea of salts, we get into great difficulties. For instance, Prof. Hittorf has said that electrolytes are compounds which by double affinity may exchange their elements with those of another recognised electrolyte. But that is not generally true. First, we have certain bodies which seem not to be decomposed by the current, though they exchange their elements with those of other compounds which are electrolytes. Take, for instance, anhydrous hydrochloric acid. It does not conduct. Nevertheless, as Dr. Gore has shown, if you put it upon carbonate of lime, the carbonic acid is chased away and chloride of calcium is formed. And, to give another example, the chloride of propyle is a non-conductor; nevertheless, when you treat it with bromide or iodide of silver the chloride gets changed into bromide or iodide.

With just reason you may object that this is no proof, for perhaps the chloride of propyle is only a very bad conductor; therefore the current does not pass in a sensible way, and we cannot observe the decomposition. In this respect we may refer to the researches of Mr. Bleekrode, in Holland, and Mr. Bartoli, in Italy.

* Read before the joint sitting of Sections A and B at the British Association Meeting, Manchester, 1887.

But, on the other side, we find well-known electrolytes exchanging their ions with elements of other compounds which, without any doubt, are not their ions. So, for instance, chlor-acetic acid ($CH_2ClCOOH$), or the ethylic ether of this acid, and iodide of potassium exchange between each other the chlorine and iodine, though assuredly the ions of chlor-acetic acid are not Cl and CH_2COOH, but CH_2ClCOO and H.

Another difficulty is offered by the alloys. A former observation of Mr. Gérardin that amalgams of sodium grow brittle on one or the other electrode was refuted in my laboratory about eleven years ago by Dr. Obach.* His researches were made with the greatest care, and extended over different alloys, even those which contained definite equivalents of their elements, and which from their other properties seemed to be definite chemical compounds. But no decomposition was observed. Somewhat later Mr. Haga, in Holland, made analogous experiments with the same result. It would give me great satisfaction if Prof. Austen should confirm these observations.

After these experiences we must confess that as yet we do not know the general definition of an electrolyte and of its ions.

II. There is another open question, whether water takes part in the electrolysis of a dissolved electrolyte. You have heard from Dr. Lodge that the answer to this question is generally negative. On the other hand, Prof. F. Kohlrausch,† in his very remarkable paper on the conduction of some electrolytes in very diluted solutions, came to the opinion that in these solutions water is also decomposed. It would be very desirable that further researches should be made on this subject.

III. Let us neglect the surely very insignificant decomposition of water, and assume that it plays only a secondary part in the electrolysis of solutions. Then we may enter upon the consideration of their electrical resistance.

It is now generally admitted, as I detailed so long ago as the year 1858,‡ that the electrical resistance of a solution is determined by the mechanical resistance (friction) the bodies set free by the current encounter in the liquid, by which means the lost motion is transformed into a quantity of heat proportionate to the electrical resistance. In the same year I *compared* this friction with the viscosity of the liquid. I believe this has been often misunderstood, for I find it stated in some memoirs that I should have said the viscosity of a liquid *represents directly* its resistance. On the contrary, and specially in a paper of the year 1856, I have shown that the friction corresponding to viscosity is different from the friction in the electrolysis of solutions.

In the year 1870, in the second edition of my "Treatise on Galvanism," Vol. I., p. 432, I have further detailed the three points separately to be considered in this electrolysis, viz., 1st, the friction of the ions in the liquid; 2nd, the friction of the dissolved electrolyte in the liquid; 3rd, the friction of the whole solution in the vessel, the electrical endosmose. I am happy to state that on these points I agree with my excellent friend, Prof. Quincke, who independently and nearly contemporaneously evolved the same ideas.

We will omit the electrical endosmose, which can be eliminated, and deal only with the first two points.

The friction of the ions alone has been further treated by Prof. F. Kohlrausch, and with the help of the admirable experiments of Prof. Hittorf on the migration of ions, and his own most elaborate researches on conductivity, he has shown that, independently from the compound decomposed, each ion has its own constant velocity in the same solvent. The discrepancies which were observed in stronger solutions disappear, as Prof. F. Kohlrausch has stated, in most dilute solutions, where the friction on the water is almost the only thing to be considered.

But with regard to very dilute solutions, I believe we encounter some great difficulties, at least for certain compounds.

1st. There may be double decomposition of the dissolved electrolyte with the impurities of the solvent. In very diluted aqueous solutions these impurities, even in the cleanest water, conduct better than the dissolved solid. It may be that this double decomposition may have no great influence on the results.

2nd. A greater influence can be exerted by dissociation of the salts. It is known that solutions of sulphate of copper, &c., are acid, that a solution of chloride of magnesia when boiled emits vapours of hydrochloric acid, that chloride and other salts of ammonia are dissociated in their aqueous solutions, &c. The increase of the dissolving water must increase these dissociations.

3rd. In many cases we are not sure if the dissolved electrolyte is to be regarded as free from water or as a hydrate (in alcoholic solutions as an alcoholate). By the researches of Graham, Rüdorff, and others, we know that such hydrates exist in the solutions. Now Prof. F. Kohlrausch, in his already quoted memoir (p. 201), has found no influence of the formation of hydrates. On the contrary,

* Obach. *Pogg. Ann. Ergänzungsband*, 7, p. 230. 1876.
† F. Kohlrausch. *Wied. Ann.* 26, p. 211. 1885.
‡ G. W. *Pogg. Ann.* 104, p. 169. 1858.

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Prof. Eilhard Wiedemann, of Erlangen, has observed that there is a definite influence. You know that chloride of copper in very concentrated solutions is green, in more diluted, blue. This change of colour is, without doubt, produced by the combination of the salt with the water. In the same manner diluted blue solutions grow green by a rise of temperature. Now the electrical conductivity of solutions of this salt at each rise of temperature of 5deg.C. augments nearly by the same amount up to 60deg.C. ; but above 60deg.C. the change of conductivity for 5deg. falls off in a remarkable manner. The same is to be observed when the solution contains free hydrochloric acid. A solution of chloride of sodium—which salt forms no hydrates at not too low temperatures—shows no such irregularities. Its conductivity rises faster than the temperature up to higher temperatures. These experiments shall be further followed up. Without doubt the number of the salt molecules combined with hydratic water must increase with the dilution.

It seems to me at present impossible to avoid these disturbing circumstances, which nevertheless should be put into consideration. Therefore we should not content ourselves with the determination of the conductivities of very diluted solutions, by which certain complications are avoided, but new ones may be introduced. Only by the study of gradually changing concentrations of the solutions at different temperatures, and comparing their electrical behaviour with their other physical properties, may we get an insight into these different conditions.

The formation of hydrates of the salts and their dissociation must also be understood before we can enter with any hope of success into further discussion of the highly interesting and important question, principally treated by Dr. Svante Arrhenius, whether the eventual formation of complex molecules and their dissociation by further dilution may have an influence on the number of molecules decomposed by the current, and on the resistance of the solution.

For the same reason the question how much of the resistance may be due to the friction between the undecomposed salt and the dissolving medium, which have a certain difference of electrical potential between each other, and therefore are transported in opposite directions by the current, must be postponed for further researches.

IV. Another point which merits ample consideration and serious criticism is the supposed relation between molecular conductivity and chemical composition. The conductivities of dissolved salts give no such immediate relation ; nor is any to be expected, since they are dependent upon the sum of the velocities of the two ions. The same may be said about the conductivities of worse conductors, the organic compounds, &c.

Great care should be taken in these researches to employ only chemically pure substances. After the interesting observations of Mr. Ramsay about the boiling points and vapour tensions of organic compounds, it seems not to be sufficient to content ourselves with getting them from even the best chemical works and testing them by their boiling points, the more so as the conductivities of bad conductors may be considerably changed by the addition of very small quantities of other substances.

By a long series of careful experiments Prof. Ostwald has tried to find between the mono, bi, and tri, valency of the acids, and their molecular conductivities in very dilute solutions, a relation which should be in inverse ratio to the valency ($100 : 50 : 33\frac{1}{3}$) ; but it seems not to follow from his researches ; as, in solutions of different acids containing only one molecular weight in grammes in 1,000 litres of water, the numbers for the molecular conductivities vary for the monovalent acids between 112·5 (HBr) and 12·65 (isobutylic acid), for the bivalent between 113·4 (H_2SO_4) and 16·91 (succinic acid). The different changes of the molecular conductivities with increasing dilution (from 100 to 1,000 litres of water for H_2SO_4 from 102·7 to 113·4, for isobutyric acid from 4·41 to 12·65, &c.) cannot encourage to a very far extended extrapolation which might conduct to the above law.

Therefore till now we must content ourselves with some minor regularities.

One of these has been observed in the laboratory of Prof. Eilhard Wiedemann by Dr. Hartwig. According to his experiments the conductivities of the acids of the fatty series attain with rising concentration their maximum the earlier the more carbon they contain, and the later the more carbon the dissolving medium (water, methylic, ethylic, amylic, alcohol) contains.

V. Also the attempt to measure the chemical strength of the acids by their molecular resistances seems to me to depend upon an erroneous conception. Already in my "Galvanism" I have mentioned that the electrical resistance offers no measure for the so-called "force of decomposition," and therefore, also, not for the chemical affinity. May we assume the former view, that the ions of a compound are directly separated by the current, or according to the now generally received theory of M. Clausius, that their motion is directed, or accelerated by it in a certain direction ; after its interruption the electrolysed solution between the electrodes and far from them is quite unchanged. The work done by the current in separating the ions or changing their motion is totally regained by their recombination or their return to their former state.

The chemical affinity, or, more rightly, the heat of chemical combination, is measured by the electromotive force ; and I believe that the law of Sir William Thomson, that the electromotive force of a cell is equivalent to the heat evolved in it, is true, if only we distinguish between the true primary chemical processes, which alone determine the electromotive force, and the secondary ones. For instance, in the magnesium cells we must calculate amongst the primary processes the formation of a highly negative suboxide of magnesium, in the cells with two liquids we must consider that their ions at their plane of separation appear and combine with each other in single atoms, while we measure directly their heat of combination when bound together into molecules, &c. In my "Treatise on Electricity," Vol. II., p. 892, I have, though but in a very few words, indicated some of these circumstances, which may explain the apparent objections to the law of Sir William Thomson. But these considerations would lead us too far from our proper subject.

VI. More intimate appear the relations between electrical resistance and the time for the formation of chemical compounds. In fact, this time depends (1st) on the affinity of the elements entering into combination or being exchanged between two compounds ; and (2nd) on the mechanical resistance which they find, while approaching each other, and which mostly has been totally neglected in these questions. Both conditions must find their expression as well in the modern theory of atomistic and molecular motion as in the older one. The first of these conditions does not enter in the consideration of electrical resistance, the second does, so that even when in both cases the processes were quite the same, we could not expect a proportionality between the time of combination and electrical resistance. Nevertheless, the experiments of Prof. Ostwald,* though treating very heterogeneous processes, indicate that between the time for the inversion of cane sugar, the catalysis of acetate of methyl by different acids, and their electrical resistances, there may be a certain relation ; though the numbers, as may be expected, show considerable differences : (if we put these constants for HCl equal to 100, they are for some other acids 65·1 and 73·4, 79·9 and 91, 74·6 and 104).

It seems to be very difficult, even if possible, to study both conditions which determine the velocity of the formation of compounds separately, and then compare only the resistance to their formation with the resistance opposed to their ions during the passage of the current.

So we see that a great deal of work has yet to be done in electrolysis, and I hope that the impulse given by the Committee of the British Association will mightily contribute to advance our knowledge in this most complicated and difficult problem.

DISCUSSION.

Prof. QUINCKE: I can endorse the views of Prof. Wiedemann about the influence of the secondary decomposition in the solution of solids in different liquids, and I think it very difficult to distinguish between the primary and secondary actions. I think we shall have a clearer view as to the decomposition of electrolytes if we employ other physical methods to trace very small quantities of the solids or of the ions of the solids—and to decide if we have secondary or primary decomposition in electrolysis. For instance, I think that the new researches of Prof. Lodge, on the migration of the ions in thermometric tubes and in jellies, will bring out new facts so as to enable us to understand electrolysis and how the chemical compounds are decomposed in the different solutions ; and I hope to learn something also from these different numbers (referring to Mr. Fitzpatrick's diagrams on the wall) of the decomposition of different solutions of the same solid in different liquids.

Prof. ROWLAND, having been invited to speak, said that this was a subject which he had not studied, and therefore he could not make any remarks on such elaborate investigations.

AMERICAN NATIONAL TELEPHONE EXCHANGE ASSOCIATION.

UNDERGROUND TELEPHONE WIRES AT BROOKLYN.

BY W. E. SARGENT.

In my remarks on underground work last year the style of our creosoted wooden conduit was fully described. In the latter part of December, 1886, in consequence of the passage of an amendment to the existing ordinance by the board of aldermen, the commissioner of city works refused to issue permits for opening the streets. For this reason our underground work has been at a standstill. We had submitted plans for 1887 for six miles of creosoted wooden conduit, which were approved by the subway commissioners, but, for various reasons, an application to the courts for

* Ostwald, *Journ. für praktische Chemie*, N.F. XXX., pp. 93—225 1883.

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a *mandamus* has been delayed until now, and a decision is expected in the next few days. The Dorsett conduit, five miles in all, connecting Brooklyn and Williamsburg, when completed, proved to be very defective. The faults in it are due to several causes, but chiefly to carelessness in laying it in the ditch and making the joints. After a great deal of work, occupying all this year, the ducts are now reported ready for occupancy. The Dorsett material is very rough, and at the joints it squeezed through the cracks, making projections that were broken off in the process of clearing out, and brushes had to be run through to clear these pieces out. Even now the ducts are so very rough that a lead cable is badly scratched in hauling in. It was claimed this material was gas-tight, water-tight, and even mud-tight, but all of these things have been found in the ducts and manholes. The only explosion of gas we have had in Brooklyn was in a Dorsett manhole. Recently the elevated railroad people exposed about eight feet of the first creosoted wooden conduit we laid three years ago. There is not the slightest decay externally, and the ducts inside are clean and dry, the friction rollers running as smoothly as when first laid. Looking backwards, we feel that, had we to do the work over again, we should enlarge the ducts to 3 × 3in. inside on double or treble their number, because we now see that with increased diameter necessary in cables and the use of double conductors, our space will soon be exhausted. We had expected to be able to lay six miles of conduit this year, which would make a total of twenty miles. This work was prevented by the conflict of authority between the subway commissioners and the board of aldermen. No change has been made in our plans for distributing, and we expect to do this from terminal poles and housetop fixtures. The Brooks cables, covered with pure lead, have now been in service three years. The corrosion of the lead pipe noted last year is still going on, with indications that it will take several years more to reach the insulated wires. The Western Electric cables, lead with a small percentage of tin, placed in the same conduit at the same time, show only a thin hard white scale, with no indications that it is increasing. The New York and New Jersey cables, covered with lead and tin, have been in the conduit about nine months, and they show no corrosion beyond a thin scale. I think we may assume that a composition of lead and tin resists the action of the gases in the underground conduits. We now have eighteen cables, aggregating 1,700 conductors, leading out underground from our Brooklyn central office—939 of these conductors are in actual service; six cables, aggregating 500 wires, leading out from the Bedford office—175 of these conductors are in actual service. We have, all told, sixteen miles of cables underground; 1,500 miles of conductors, 900 miles of which are in actual service. The cables leading out from Brooklyn central office range from 900ft. to 7,180ft.; in Bedford from 460ft. to 2,250ft. The first cables furnished by the Western Electric Company, 100 wires mixed indiscriminately, have been in service since November, 1884, and have given satisfactory service, with one intermission on account of defective terminals. This difficulty seems to have been solved by their last device for that purpose, and no serious decline in the insulation has occurred for the past two years. The wire used in all our present cables is ·035in. to ·038in. diameter, with insulation ·075in. to ·088in. Realising that metallic circuits will be necessary in underground work, all our cables were ordered twisted in pairs or groups of four. Through a misunderstanding, a portion of the cables were furnished indiscriminately. We now have cables with the conductors related to each other in three different ways. It was found at once that the cross talk between two of a pair, or two of four, was too great for satisfactory service. There is no cross talk between the pairs or the groups of four. One cable of 7,160ft., 100 wires twisted indiscriminately of the Western Electric manufacture, has some cross talk, but not enough to prevent its use, and 84 of the 100 wires are in active service. The insulation of the cable varies from 650 to 450 megohms in summer, and the capacity is ·227 microfarad per mile. The next in length was made by the New York and New Jersey Telephone Company, 6,660ft. with 100 wires twisted in pairs. The cross talk between pairs was so bad that we were compelled at once to take measures to remedy it. The joints were opened and the pairs broken up at all the manholes at intervals of about 800ft. The effect of this work was to reduce the cross talk between pairs and distribute it among all the wires. It may be expected, of course, that more frequent transpositions would make the cable just as good as the Western Electric. This is not practical, and we shall restore the wires to their original relations, grounding the twin wire until the metallic circuit era arrives. The insulation of this cable ranges from 54 to 29 megohms per mile, and the capacity is ·3 microfarad per mile. Thirty subscribers are working through it. The shorter cables give similar results, diminishing proportionately to the length. To connect our Brooklyn central with branches at Bedford and Williamsburg will require two and a-half to three miles of cable, and we believe if we followed the Western Electric type there would be enough cross talk to make them valueless, or if we ground the twin wire in the New York and New Jersey type we believe there will be retardation enough to make serious trouble. We have therefore decided to make our long trunk lines of copper ·050 in diam. and insulation ·125 in diam. This reduces the copper resistance nearly one-half, and increases the thickness of the insulation. Sixty wires of this size may be put in 1⅛in. core, making a cable with an outside diameter of 1½in. We are restricted to this size by the 2in. holes in the Dorsett conduit. The insulation of the Western Electric cables quoted shows there has been no reduction since the last terminals were put in. The N. Y. and N. J. cables do show loss of insulation, but we attribute this to the joints and terminals, our men lacking skill and experience. Time will prove this, and, other things being equal, we believe both cables will give good results. A 25-wire okonite cable was drawn into the creosoted wood on ducts in the summer, when it was moved to make room for more wires. There is no sign of deterioration or decay in the rubber, and the insulation is 150 megohms per mile in water since it was taken out of the conduit.

It is generally believed that rubber cables will be damaged or destroyed by lying in creosoted wooden ducts, unless protected by lead. It would be interesting to make further trials to demonstrate whether this be so. For terminal wires leading from the conduit to the building some form of rubber or gutta percha wire is the most convenient.

UNDERGROUND AND AERIAL TELEPHONE CABLES AT CHICAGO.

BY E. B. SUNNY.

A mile of Patterson cables has been put down in West Madison-street, in Chicago, made up of one 150-wire cable and cables of from 25 to 125 conductors, containing in all about 200 miles of wire. No. 18 American gauge was used, and the insulation and capacity tests are very satisfactory. These cables were put down to abandon a pole line of ninety wires built about six years ago. Notwithstanding the fact that the wires on the route were badly decayed, and contained many defective connections, and that the cables were of the best manufacture, the wires on the pole route talked about 25 per cent. better than those in the cables. The cross talk is only noticeable at times, and is not heavy. These cables are laid in a box of creosoted wood and covered with ¼in. tarred sheet iron. The box is just big enough to take the cable, and no filling of any kind is used. A gang of twenty men put this cable down at a rate of 500ft. per day, finishing up everything excepting the permanent restoration of the pavement. Eleven hundred feet of conduit has been built to carry the cables from the present central office to the new building. The construction includes the use of wrought-iron pipe 2½in. inside diameter, free from burs and presenting a smooth surface to the cables. The pipes, sixteen of them in all, are spread apart, and the interstices filled with concrete. We are putting 18-gauge 200-conductor cables into the pipes, and find that they work smoothly, and that a gang of six men can put in four pieces of cable 400ft. each per day. The underground cables put down two years ago are giving satisfaction. Recent tests on some of them show an insulation ranging from five to fifteen megohms. One cable put down by the Standard Company two years ago indicated a very low insulation on the regular test. We opened the street in two or three places, and finally located the fault in a splice. No abrasion of the lead pipe could be noticed, nor was there any superficial evidence of a fault. A piece, including the splice, was cut out, and another piece of cable put in. The piece cut out was laid on a board, and shortly it was noticed that water was coming out of the splice through a blow hole the size of a pin in the solder. There was perhaps half a pint of water in the sleeve. It took two years for the fault to develop. In another instance a standard cable was cut into by plumbers some time last November. In June the insulation was found to be low, and when the fault was located it was discovered that the water had gone into the core through a bad cut in the lead, and had worked back 40ft., requiring new cable to that extent. We have several cables, chiefly aerial, that are defective, and are being looked up. It requires the constant attention of a galvanometer corps to keep them in good shape. By means of semi-annual tests defects have been discovered and removed before they had time to affect the service. The trouble from low insulation at the terminals is being overcome by filling the terminals with paraffin wax, or some other insulator, and keeping the terminals well protected from moisture. The trouble outside of the terminals on air cables is made up of cuts in the lead by hooks cutting through, bullet holes, and careless workmen. The following test, recently made, may be of interest:—Two wires were selected which ran together, through nine cables of seven different styles, a distance of 4·4 miles. The cables are Patterson aerial and underground and standard aerial and underground, and contain from 50 to 150 wires, each ranging from 18 to 26 gauge. The resistance measures 444 ohms. The first test was made on a day of alternate sunshine and rain, when everything was damp. There was abso-

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lutely no cross talk from one wire to the other, and conversation could be carried on freely and without any more effort than on an air line. The introduction of an annunciator drop into the circuit made no difference. A test for insulation showed 400,000 ohms for the distance and a static capacity of 1·4 microfarad. A week later the same wires were used in the same manner with less satisfactory results. The weather was dry and warm. It was found that counting on one could be distinctly followed on the other, and *vice versâ*. The cross talk from the other wires was very noticeable, but not of sufficient volume to disturb the user. Conversation at a distance of eight inches from a fairly adjusted transmitter was indistinct and muffled. With the lips close to the transmitter, and by speaking in the usual tone of voice, the results were fairly satisfactory. This was particularly true when an air line of one and a-half mile was added. The measurements made after the test showed the insulation to be 4 megohms for the distance, against ·4 of a megohm on the previous test, and 1·05 microfarad capacity against 1·4. By opening one of the wires at both ends, so that all connection with the earth was removed, conversation could be freely carried on between three parties who were looped in. The first one was 5,000ft. from the open end of the cable, and the other 12,000ft. The only difference noted by the intermediate parties in the working of the wires with the ends open was that the cross talk was much heavier than with the grounds on. The second test indicates conclusively that we have used up all of our margin and that a slight addition to the length of the cables will make the connection of no commercial value. In fact, in ordinary dry, clear weather, conversation is only carried on by frequent repetitions and considerable discomfort. The nine cables included in this test are all in good condition, and with the exception of a few pieces of air cable, are new. On the above circuit there are sixteen terminals in use, but in all cases, except in exchange offices, the cable wires of one cable were connected with those of another at the terminals with kerite or okonite wire, so that the insulation was good at these points. The experience of four years has proved the fallacy of the practice of requiring the manufacturers to furnish a cable showing an insulation of from 300 to 800 megohms per mile. While this insulation can be secured immediately upon the completion of a cable, it is utterly impossible to maintain it. Nor is it desirable to maintain it, for the reason that cross talk is greater on a cable with a "fancy" insulation than in one of a megohm. Subscribers always complain of cross talk when their wires are put into a new cable, but after a few months we hear no more about it. This is not so much because they have become accustomed to the cross talk as it is that with the lowering of the insulation the cross talk is decreased. A better specification would be one megohm per mile and not more than five, and a guarantee from the manufacturer that this insulation will hold up for ten years. Such an insulation exceeds anything that we are able to get on air lines. In a recent test nine wires showed each an insulation of 5·3 megohms. Rain began to fall, and it ten minutes the insulation had fallen off to 3·2, and no doubt went lower. This illustrates the extreme sensitiveness of a high insulation to moisture, and indicates clearly that where there is a large number of cables in use the conditions are constantly varying, and nothing like uniformity in the working of the wires can be expected or secured.

ON JOINING LEAD-COVERED CABLES.

BY MR. PATTERSON.

The only thing to look out for in making a joint in a lead-covered cable is to keep out moisture. The ends of the cable, after the cable is made, should always be sorted out. Then after the cable is drawn into a conduit, the end of the pipe is cut off and the pipe removed from the core for a distance back corresponding to the size of the cable. For a 100-wire cable we would want to strip about 18 or 24 inches on each end. On the new style of cables arranged for metallic circuit each pair of conductors are twisted together and served with a single splint of cotton. The serving around the two wires will hold them in place until the man who is doing the splicing deliberately removes it. One is covered with white cotton and one with red and white—some colour that can be easily distinguished. The two wires are brought together, and the way we generally make a splice, and the best way, I think, is to strip the wires for an inch and a-half, bring them together, and instead of making a long splice, bend them up and then twist the ends together. That will leave the wire running through and the two ends twisted together standing at right angles to it. A cotton sleeve is drawn over it. This sleeve is like the outer braiding of office wire. After all the wires are spliced in that way they should receive a bath in very hot paraffin, poured on while they are laid out loosely to remove moisture, which they may gather from the atmosphere and from the hands of the men. Then the core should be covered and brought down to a compact size, that the lead sleeve will slip back over it. After that sleeve is on it should receive another paraffin bath. After the work is all done it is well to take a torch or something of the kind and pass it along underneath the cable and melt the insulation for a distance of one or two feet each side, so as to put on a pressure and test the joints; if there is any flaw it will show itself by the paraffin oozing when the pressure is put on. Occasionally, in underground work, it is not convenient to make a sleeved pipe. In that case we turn both ends of the cable up and bring them out through the top and have a brass casting in the form of an inverted Y. The two branches of the Y are of such size that the cable pipe will slip into them, and the main outlet is large enough to make the splice. The wires are brought up through it and spliced together, and the opening covered by a cap. After the work is done, that Y is dropped down into the hole and lifted. That removes the necessity of doing the work in the manhole. It is lifted up to the level of the street, and the man sits on the edge with his feet inside and works on it.

COMPANIES' MEETINGS & REPORTS.

The Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-eighth ordinary general meeting of this Company was held on Wednesday, 26th October, at Winchester House, 50, Old Broad-street, Mr. John Pender in the chair.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed and signed by the Chairman as correct. The report and accounts were taken as read.

The CHAIRMAN: I will, with your permission, now give you a few details as to the last half year's working. The gross receipts for the half year were £219,201, against £224,843 for the corresponding period of 1886, or a decrease of £5,642. This result, however, is not unsatisfactory having regard to the fact that in the corresponding period the reduced tariffs had not come into operation. The reductions agreed to at Berlin were, however, based on the figures of 1884 and 1885, which were the best years we have ever had, and although we shall this year carry a larger number of words than in 1884, we shall have only made up about £18,000 of the loss of £50,000 per annum, which was estimated from the reduced tariffs, leaving over £30,000 still to be recouped. As the traffic is increasing this loss will doubtless be made up in course of time; but our experience shows that the traffic does not respond so readily as the advocates of low tariffs would have us believe. The expenses for the half year were £76,241, against £81,775 for the corresponding period of 1886, showing a decrease of £5,534, which is due to our having disposed of the "Agnes," and having consequently had during the past half year only two maintenance ships, against three in the corresponding period of 1886. The net revenue for the half year was £97,662, against £97,480 for the corresponding period of 1886, showing an increase of £182. One quarterly interim dividend of 1½ per cent. has been paid during the half year, and another of like amount was distributed on the 15th inst., leaving £35,162 to be carried forward to the current half year, at the end of which the question of bonus distribution will be dealt with. I have during the last week, since the report was issued, received six letters from shareholders on the subject of the printed accounts, three of them having reference to the non-payment of a bonus for the half year. It was, however, always understood that any bonus that might be declared should be paid at the end of the year after having ascertained the result of the year's operations. We were, however, at one time urged by some of our shareholders—in 1884 or 1885 I think it was—to make the distribution half-yearly, which we did for several years, but after the reduction that we had to submit to at Berlin we thought it was more desirable to postpone it till the end of the year. No doubt at the end of the current year we shall be able to pay a portion of it at all events, and thus redeem our promise as we did in previous years. There have been no serious interruptions to our system during the past half year, although numerous repairs have been effected, and all the sections, excepting the Tonquin-Hong Kong cable, which is at present undergoing repair, are now in good working order. Since the close of the half year under review a further portion of the Singapore-Saigon section, which is the only main cable unduplicated, has been renewed with brass-ribboned cable to the length of 174 nautical miles, leaving about 150 nautical miles to be renewed. This will, in all probability, be completed during the current half year, in which case the cost of the operation will be shown in the next published accounts.

This question of the renewal of cables, and the damage effected by the teredo is a very important one. We had for many years constant cause for repairs by the action of that insect, but we set our brains to work, and the result was that we hit upon a plan which has greatly obviated the difficulty, by using brass-ribboned cable. The following statistics will show the value of brass-ribboned cables in teredo-infested waters:—Before the Singapore-Batavia cable was renewed in 1881 no less than 194 faults were removed in 11 years, or on an average 18 a year; whereas, during the last six years only four breaks have occurred, and these have been entirely due to ships' anchors. On the Banjoewangie-Darwin cable 67 faults occurred before it was partially renewed in 1884, since which time not one fault has occurred in the brass-ribboned portion. The same remark applies to the Singapore-Saigon cable, which was partially renewed in 1885, although forty-nine faults had previously occurred. Consequently our experience, extending over a period of nearly seven years, clearly shows that

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the brass-ribboned cable has successfully resisted the attacks of the teredo, from which we sustained so much damage until we adopted this valuable form of protection. The Company's new shore cable establishment at Singapore, in place of the hulk, "Southern Ocean," has been completed, and the tanks and machinery from the latter were transferred to the shore establishment before the hulk was sold by public auction.

At the last meeting I went fully into the details of our relations with the Australian colonies and New Zealand, and have now only to state that during the last six months, since the return of the delegates to their respective homes and Governments, nothing has been done. At the end of next month, I believe, there is to be a conference at Adelaide to consider the question of cheaper postal rates and lower telegraph rates between the mother country and the colonies; and until the Directors hear of the decision arrived at their policy will be to leave things alone. Since the last meeting of the Company a fresh Parliament has been elected in New Zealand, and the Government from whom the Company had differed were out of power. As soon as their successors have had a little time to settle down the Directors will resume the correspondence, with, I hope, a fair prospect of success. The Company have been in negotiation with the Chinese Government during the half year, and have tried to show that Government that submarine telegraphs were a great necessity for China, and the Chinese Government endeavoured to prove that land lines would beat the submarine system. The result has been that an understanding has been come to by which both interests will be properly protected. The points of the agreement have been settled, and it simply awaits the approval of the Chinese Foreign Office; and when that matter is settled I hope that for the next sixteen years we shall be able to look at the growth in the China trade without any fear of undue competition. I may mention that nearly the whole of our system is duplicated—I might almost say, triplicated—so that we are in every way in an efficient condition for the conduct of our business. Our relations with the Imperial and Colonial Governments are of the most friendly nature. The other day the Imperial Government laid down a cable to Port Hamilton, which they afterwards found they did not require, and we took the opportunity to take it off their hands at such a price as would enable us to utilise it with advantage. I think that I have gone over all the points that it is necessary to call your attention to, and I will finish by saying that our relations with all foreign Governments are very satisfactory and our revenue is increasing, and I hope by the time we meet you six months hence we shall be able to show that there has been considerable progress for the half year, and that we shall be able to resume the payment of the bonus. I will conclude by formally moving the adoption of the report and accounts.

The Most Hon. the Marquis of TWEEDDALE seconded the motion, which was carried unanimously.

A vote of thanks was afterwards passed to the Chairman and Directors, and the proceedings terminated.

Hammond Electric Light and Power Supply Company (Limited) (in Liquidation).

An extraordinary general meeting of this Company was held at Winchester House, Old Broad-street, yesterday (Thursday), under the presidency of Mr. William Theobald (the liquidator).

The SOLICITOR having read the notice convening the meeting,

The CHAIRMAN, in the course of his remarks, said: I feel that before I go to the report I should refer to the circular issued in April last, stating that we should probably call a meeting in the following June. Soon after that circular was issued I found, on looking into the matters outstanding, that they were so few and of such little value that if I deferred calling the shareholders together for a little while, I should be able to place before you the final accounts, and that I am able to do to-day. I have the pleasure of presenting the following report upon my duties as liquidator, which I venture to think will reveal a more satisfactory result than was at one time anticipated. On the 10th of June, 1885, I was appointed by the Chancery Division of the High Court of Justice provisional liquidator of your Company, with power to carry on the business, so far as was necessary for carrying out and completing existing contracts, and to pay wages and other charges. On the seventeenth day of the same month, at an extraordinary general meeting of the members it was resolved that the company should be wound up voluntarily, and I was appointed liquidator. The following shareholders were at the same time appointed a consulting and advising committee, viz.:—Messrs. E. H. Brown, A. M'Alister, and F. W. Reynolds. Immediately on taking possession of the assets and undertakings of the Company, including as they did important uncompleted contracts, it became apparent that many of them were of a very special character, their advantageous realisation demanding personal and most careful consideration, and I have to acknowledge the valuable assistance which was afforded me at this time by the advising committee. Valuable assistance was also rendered from time to time throughout the proceedings by Mr. Robert Hammond, which has been of substantial service to the liquidation. The peculiar nature of the difficulties attending the realisation of some of the assets may be best exhibited by a few examples [which he proceeded to give]. A lighting station at Brighton had been worked for some time, but was in a very incomplete state, and under the conditions of the lease certain of the engines used for driving the dynamos had to be removed. Although there seemed every probability that by expenditure of additional capital the lighting station might be placed on a profitable basis, it was doubtful if at that time it was paying expenses. A contract for management for a term of years had been entered into with the Eastbourne Electric Light Company (Limited), under which the Hammond Company were to bear all losses or take the profits, if any, on the working; they were also to provide the requisite capital for extension purposes, and to receive payment in debentures of the Eastbourne Company. A similar contract had also been entered into with the Hastings and St. Leonards-on-Sea Electric Light Company (Limited). Under the two last-mentioned contracts the Hammond Company had become entitled to debentures of the Eastbourne Company for about £7,050, and of the Hastings and St. Leonards Company for about £3,300. In the case of the Eastbourne Company the debentures, jointly with others to the extent of £500, formed a first charge upon the assets of the Company; but in the case of the Hastings Company the debentures only ranked after a charge for £4,000 given to the bankers. Neither of the above companies were paying expenses; and after careful consideration it was decided to risk the refusal of supplies to the Hastings Company (fortunately without causing a stoppage of their business), but to carry on the Eastbourne contract for a time in the hope of obtaining a purchaser for the debentures, who would also undertake to perform the contract. With this object in view the liquidator made overtures to the Anglo-American Brush, the Edison and Swan, and other electric light companies. Protracted negotiations and correspondence also were carried on with the representatives of all the various interests concerned, but without satisfactory result; and after long and tedious efforts to sell by private treaty it was determined to offer for sale by public tender not only the Brighton Lighting Station, the Hammond Company's interests in the Hastings and St. Leonards-on-Sea Electric Light Company, and the Eastbourne Electric Light Company, but also what remained of the hiring installations in other parts of the country. Advantage was taken of the issue of a circular by the Consulting Committee on the 16th September, 1885, to forward a copy of the advertisement of this sale to every shareholder on the register. Offers were received for each of the properties mentioned, some of which were immediately accepted, but in other instances improved prices were obtained by subsequent negotiations. The issue of the tender forms and the acceptance of each offer were made with the approval and under the direction of the Court. I found it impossible to arrange any scheme for the reconstruction of the Company; and as inquiries are still occasionally made on the subject, I cannot do better than quote from the circular of the committee above referred to, in which they say:—"Since you appointed us to confer with your liquidator, we have carefully considered the possibility of a resuscitation of your Company, and we regret that we are unable to recommend such a course. The large amount of liabilities and claims, about £20,000, and the peculiar nature of the assets, would necessitate an immediate subscription of considerable capital, which we do not feel justified in asking the shareholders to find." They added—"We fear the prospect of any return being made to the shareholders is extremely doubtful." Since issuing this circular in September, 1885, the committee have taken no part in the management of the liquidation, feeling that the shareholders were not likely to obtain any benefit from their labours, and having at the meeting convened by the above circular resigned their position. Another of the undertakings in connection with, and, in fact, forming part of the Hammond Company, which at one time seemed likely to involve many troublesome claims for uncompleted contracts, was the Electrical College, in Red Lion-square. Having explained the steps taken in this matter, he added:—All the claims from the parents and guardians of the students, which at one time seemed inevitable, were avoided. Not one claim was sustained, and I believe general satisfaction was given. In conducting the liquidation it was often difficult to decide how far it was advisable to carry out contracts for work on hand and hiring contracts, and whether less loss would be incurred by breach of the contract than by completing it. The labour of realising the estate and in settling the claims has been much heavier than was at first anticipated. It is a source of pleasure to me, therefore, to be able to report that, whereas at one time it seemed doubtful if even the creditors would be paid in full, I am able to report to-day that they have all been paid, and it is proposed to make a return of 3s. per share to the shareholders. When the property came into the hands of the liquidator a large amount of the stock was in an unfinished condition. After careful consideration it was determined to complete as many dynamos as possible before offering them for sale. Several offers were received for part of the plant and stock by private treaty, but the difficulty of fixing prices being considerable, and some of the offers received being absurdly small, it was decided, with the full concurrence of the committee, that all should be offered by public auction, excepting sales at current prices. In accordance with that decision, the whole of the plant, stock, and apparatus at the factory in Appold-street, at the stores in Bermondsey-street, at the lamp factory in Bermondsey, and at the Electrical College in Red Lion-square, were offered for sale at public auction, the sale occupying seven days. The amount realised, after deducting the heavy expenses and the auctioneer's charges, was £11,604. 4s. The wisdom of the policy adopted, and of making so much of the sale as was done by extended advertising, was then fully manifested. The Anglo-American Brush Company's concessions and the Ferranti patents were offered at the auction sale, but no bids were made. Sales, however, have been effected subsequently at low prices. Under an agreement with Messrs. Donnithorne and Liardet, £5,695 had been deposited with Messrs. Hoare, the bankers, as a guarantee fund in connection with a contract. After referring to the legal proceedings between Messrs. Donnithorne and Liardet and the Company, in connection with this contract, he continued: Early in August, 1885, the action was dismissed with costs, and the deposit, with interest, amounting in all to £6,099. 13s. 9d., was ordered to be paid to me as liquidator. This was received on 19th November, 1885. In addition to the ordinary creditors for goods, &c., various claims arose out of royalty and other contracts; also heavy claims and complications arose in connection with the various leases held by the Company. I was enabled to settle all of these claims on favourable terms, and to get

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the Company relieved of the claims on the leases. The claims of the debenture holders, which were carrying interest at the rate of 7 per cent. per annum, were discharged under an order of the Court in January, 1886, thus stopping interest at that early date. The list of the other creditors having been settled by the Court, notice of payment in full was given in May, 1886, and all have been discharged. The provisional cash statement herewith presented exhibits the amount obtained for the various properties of the Company in a summary form only, but I shall be happy to supply such details as the shareholders may desire. The result of the liquidation shows that after paying the debenture holders and creditors' claims, amounting to £15,246, there remains a balance in hand of £8,583. There are, however, a few paper assets still to be dealt with before the liquidation can be finally closed. In conclusion, it only remains for me to remind you that when I was first appointed it was not expected that the work of the liquidation would have entailed such unremitting and personal labour, or that it would turn out so favourably to the shareholders as it has done. In view of this, your liquidator was induced to accept a fee of 600 guineas. The result of the liquidation, however, entitles him, according to the scale fixed by the Court of Chancery, to a much higher rate of remuneration, which would, no doubt, be allowed upon application to the Court, but it would be some satisfaction to the liquidator if the meeting were to pass a resolution which would certify their appreciation of his services. It is upon the official basis of remuneration, as allowed by the Court, that the accounts now about to be laid before the meeting are made out, showing a balance of £8,583. 10s. 11d, and the liquidator proposes forthwith to make a return to the shareholders of 3s. per share, which will absorb £8,401. 1s. 0d, and thus practically close the liquidation.

After a few remarks from Mr. EDENSOR,

Mr. INCE warmly commended Mr. Theobald for the manner in which that gentleman had carried out the liquidation, and he proposed a resolution, increasing the personal remuneration of Mr. Theobald to 900 guineas, on the condition that 3s. a share was returned to the shareholders.

Mr. A. M'ALISTER said that the meeting must first deal with the report and accounts.

Mr. INCE said that in point of order Mr. M'Alister was right, and he would therefore propose the following resolution first—"Resolved that the report of the liquidator and the accounts of the liquidation be, and the same are hereby, received and adopted, and that, in view of the liquidator's report, this meeting is of opinion that the whole of the outstanding assets are irrecoverable and valueless, with the exception of the iron safe and office furniture, and that the liquidator be, and he is hereby, instructed to refrain from any further effort, and from incurring any further expense in connection with attempts to dispose of such outstanding assets, and that upon the completion of the winding up the said iron safe be retained by the liquidator for the purpose of preserving until such time as the Court sees fit the books and documents of the Company."

Mr. A. M'ALISTER seconded the resolutions. He as one of the Committee of Inspection had had the opportunity of seeing the way in which Mr. Theobald had worked, and the result was that, instead of receiving nothing, the shareholders would have 3s. a share. Instead of spinning out the liquidation for years, Mr. Theobald had worked to close it as soon as possible.

Mr. F. W. REYNOLDS said that the committee had found that it would be hopeless under the circumstances to reconstruct the Company. Mr. Theobald had done everything he possibly could for the shareholders. Possibly the Company came into existence rather too soon; but he believed that all present felt that there was a great future for electricity, not only in regard to lighting, but also as a motive power.

The CHAIRMAN, in reply to a question, said that the money was all in hand, and he proposed to distribute it as soon as the circular could be sent out.

The SOLICITOR then read the resolutions, which were separately agreed to *nem. con.*

The meeting then terminated.

The Brazilian Submarine Telegraph Company.

The following is the report of the Directors for the half-year ended 30th June, 1887, to be submitted to the twenty-eighth ordinary general meeting to be held on 2nd November, at Winchester House, Old Broad-street, E.C., at 12 noon :—

The revenue for this period amounted to £100,876. 7s. 6d., and the working expenses to £13,262. 2s. 10d. After providing £14,205 for debenture interest and sinking funds, and £2,004. 17s. 6d. for income-tax, there remains a balance of £71,404. 7s. 2d.; to this is added £7,528. 5s. 1d. brought forward from 31st December last, making a total of £78,932. 12s. 3d. A quarterly interim dividend amounting to £19,500 has been paid, and £25,000 transferred to the reserve fund, leaving a balance of £34,432. 12s. 3d. The directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total dividend of six per cent. for the year, and also the payment of a bonus of 2s. per share, both free of income-tax, which together will amount to £32,500, being a distribution in the aggregate of 7 per cent. for the past year, leaving a balance of £1,932. 12s. 3d. to be carried forward. On the 30th July last the sum of £37,100 was transferred from the sinking fund to pay off the 371 bonds of the 1884 issue, drawn for redemption in April last. This repayment reduces the debenture debt to £187,900. The various sections of the Company's line are in good working order.

Sir James Anderson and the Hon. W. St. John F. Brodrick, M.P., retire by rotation at this meeting, and, being eligible for re-election as Directors, offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 21st October amounted to £4,270.

CENTRAL AND SOUTH AMERICAN TELEGRAPH COMPANY.—This company has declared a quarterly dividend of 1½ per cent., leaving a sum of $12,500 to be carried forward.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company give notice that the coupon on their Five per Cent. Manila Debentures (1880 issue) due on the 1st November proximo, will be payable on and after that date on presentation of the same at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons must be left three clear days for examination.

INDO-EUROPEAN TELEGRAPH COMPANY.—The directors of this company have declared an interim dividend for the half year ended the 30th June last at the rate of 5 per cent. per annum, being the same as for the first half of 1886.

MEXICAN TELEGRAPH COMPANY.—The Mexican Telegraph Company has declared a quarterly dividend of 2½ per cent., leaving a surplus carried forward of $11,000.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 21st October, 1887, were £3,316, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—At a meeting of the directors of this company, held on the 26th inst., it was decided to recommend to the shareholders at the approaching meeting that a dividend of 9s. per share be declared on account of arrears of dividend on the First Preference Shares.

PERSONAL.—Mr. J. H. Cundall, M.I.C.E, has taken offices at 121, Cannon-street, E.C., and commenced business as a Consulting Electrical Engineer. Many electricians will recollect that Mr. Cundall organised and superintended the lighting of the Indian and Colonial Exhibition, and the success which attended his efforts upon that occasion should go a long way towards assuring him ample support in his new career.

——— Mr. Arthur Morley, of Radcliffe-street, Islington, trading as The Vulcan Manufacturing Company, informs us that Mr. Wilson has retired from the business.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 26.		BUSINESS DONE WEEK ENDING OCT. 26. Highest.		Lowest.	
Anglo-American	38½,	39½	.....	39½	.....	37½
Do. Preferred	64,	65	.....	65½	.....	61½
Do. Deferred	14½,	15½	.....	15	.....	13½
Brazilian Submarine	11½,	11½	.....	11½	.....	11½
Cuba	11¾,	12¼	.....	11½	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅞,	3¼	.....	2⅞	.....	— xd.
Do. Preference	8,	9	.....	—	.....	— xd.
Direct United States Cable	9½,	9¾	.....	9½	.....	8¾xd.
Eastern Telegraph	11,	11½	.....	11 3-16	.....	11 xd.
Do. 6 per Cent. Preference	14,	14½	.....	14 7-16	.....	14 xd.
Do. 5 per Cent. Debentures, 1899	100,	109	.....	—	.....	—
Eastern Extension	11⅛,	11⅞	.....	11⅞	.....	11⅛xd.
German Union	10⅝,	11	.....	—	.....	—
Globe Telegraph and Trust	5⅝,	5⅞	.....	5 9-16	.....	5 7-16xd.
Do. Preference	13½,	13¾	.....	13¾	.....	13 1 16xd.
Great Northern	13½,	14	.....	—	.....	—
Indo-European	36,	38	.....	—	.....	—
Reuter's	8,	8½	.....	8	.....	— xd.
Submarine	170,	180	.....	—	.....	—
West India and Panama	⅝,	¾	.....	—	.....	—
Do. 1st Preference	9½,	9⅞	.....	—	.....	—
Western Brazilian	7⅝,	7⅞	.....	7¾	.....	7¾xd.
Western Union 7 per Cent. 1st Mortgage	120,	125	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	101,	104	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	¾	.....	—	.....	—
Oriental	½,	⅝	.....	—	.....	—
United Telephone	11,	11½	.....	11⅜	.....	11 3-16
United River Plate	4¾,	5¼	.....	—	.....	— xd.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2½,	2⅝	.....	—	.....	—
Do. (fully paid)	3,	4	.....	—	.....	—
Swan	1⅝,	1⅝	.....	1⅝	.....	—
Maxim Weston	3-16,	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37,	38	.....	37½	.....	36¾
India Rubber, Gutta Percha, and Telegraph Works	20½,	21½	.....	21½	.....	20½

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NOTES.

BRUSSELS.—A considerable length of the phosphor bronze telephone line between Paris and Brussels has been torn down by the recent gales.

LONDONDERRY.—The Corporation of Londonderry are inviting tenders for the supply of electric light. Particulars may be found in another column.

THE CARLTON CLUB.—The Carlton Club, which was re-opened this week, is now lit by Ferranti transformers, from the Grosvenor Gallery Central Station.

THE WAR OF CABLE RATES.—It is believed in cable circles that the visit of Mr. Jay Gould to this country will lead to an arrangement between the rival companies.

THE BRIGHTON ELECTRIC RAILWAY.—We regret to learn, at the moment of going to press, that the severe south-westerly gale of Thursday has caused very serious damage to Magnus Volk's Electric Railway.

TWO MEN KILLED BY LIGHTNING.—On Sunday night at Carahboge, between Killorglin and Glenbeigh, a farmer named Walsh was, during a storm, tying a cow up in a shed, his eldest son standing some yards off, when a flash of lightning came, and the two men and the cow were struck dead.

ELECTRIC TRACTION AT RICHMOND. — Messrs. Christi, James and Co.—who, we understand, are acting in this matter as the agents of a French firm—have been making experiments during the present week with a tramcar propelled by secondary batteries on the line between Kew Bridge and Richmond. We shall probably be in a position to give further details next week.

APPOINTMENT.—Mr. Samuel Vyle, of Glasgow, has received the appointment of Electrician to the Post Office of British Guiana, an office which involves the responsibility of the technical charge of the Government land lines and cables of that colony. Mr. Vyle will leave Glasgow for British Guiana about the 26th inst., and his departure will be regretted by a numerous circle of friends.

DISTURBED IRELAND.—The police authorities have issued notices throughout West Clare in reference to the cutting down of the telegraph wires between Kilrush and Ennis last Sunday. It is stated that in future where such outrages are attempted a police hut will be erected on the scene of the occurrence, and the parish will be taxed with the cost of the constabulary stationed at the hut.

HALIFAX (N.S.).—It is stated that the cable steamer "Britannia" is about to move the shore ends of the Direct United States Company's cables from Tor Bay to Halifax, which is ninety miles further South. The "Britannia" has on board the necessary lengths of new cable. The general tendency appears now to be in favour of bringing cables ashore as close as possible to the most important towns of the coast-line, instead of landing them on uninhabited spots.

TELEGRAPH STORES REQUIRED.—The directors of the South Indian Railway Company advertise for tenders for telegraph stores. Specifications (price 10s.) may be obtained from the Managing Director, 55, Gracechurch-street, E.C., and tenders must be returned by November 15.—The Cheshire Lines Committee also advertise for tenders for telegraph stores, including wire and instruments. Specifications may be obtained from Mr. W. H. Legge, storekeeper, Warrington, and tenders must be returned by December 3.

ELECTRIC WELDING.—Messrs. Laing, Wharton and Down write us as follows:—"We notice in your issue of the 21st ult. a notice relating to 'Electric Welding in Germany,' and in this connection we have to say that we are informed that active measures are being taken in that country to organise a strong syndicate to put in operation Prof. Elihu Thompson's electric welding apparatus, on which he has very valid patents, and power is now being placed for the working of welding plant, which is now on the way and will soon be in practical use."

BLACKPOOL.—The directors of the Blackpool Electric Tramcar Company held a field day on Friday last. The promenade was hung with arc lights, in which eight different systems were represented, and the tramcars themselves, as the local reporter says, "were brilliantly illuminated by the same agency." Afterwards there was a dinner, at which the Mayor of Blackpool presided, and amongst other distinguished guests there were present Mr. Alexander Siemens, the Mayors of Manchester and Halifax, and Mr. J. Oddey, an ex-mayor of Ballarat.

TUESDAY'S GALE.—Notwithstanding the violence of the gale which swept across the greater portion of England on Tuesday last, comparatively little damage seems to have been done to telegraph and telephone plant, although other kinds of property suffered severely. At Blackburn, where it was exceptionally furious, some of the wires were blown down, interrupting communication between the town and other places for about two hours. Beyond these and the destruction of one or two electric lamps at the Newcastle Exhibition no other casualties in electrical property have been reported.

THE CHANNEL CABLES.—It is stated that the Chamber of Commerce at Havre has addressed to the French Government a protest against the renewal of the monopoly to the Submarine Telegraph Company. Protests of a similar character are likely to come from Paris, Bordeaux, Rheims, and other towns. It is a little surprising that no movement has yet been made on this side of the Channel, but probably there is a feeling that the danger of the renewal of the monopoly is too remote to give cause for alarm. Still, it would be as well for those chiefly interested not to lose sight of the matter until the question has been finally set at rest.

THE LIGHTING OF THE MILE END INFIRMARY.—The Mile End Board of Guardians has obtained a report on the cost of providing their infirmary with electric light. It appears that motive power is already available in the shape of an engine employed at present for chopping wood, and hence a considerable economy is expected. The present cost of gas lighting is £356, and the estimated expenditure for electric light is £200 per annum. While it would be rash to express any opinion on these figures without knowing something more of the conditions, on the surface it is difficult to understand how the saving of £156 is to be effected, even with the engine thrown in. We make this observation in the interests of all concerned.

THE SOCIETY OF ENGINEERS.—At the next ordinary meeting of this society, to be held on Monday, 7th November, at 7:30 p.m., at the Westminster Town Hall, a paper will be read on "Primary Batteries for Illuminating Purposes," by Mr. Perry F. Nursey, past president, of which the following is a synopsis:—"Introduction. A wide field open for primary batteries. Their principles and history outlined. Descriptions of batteries for special purposes, and batteries for general lighting, including those of Holmes and Burke, Ross, Coad,

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lutely no cross talk from one wire to the other, and conversation could be carried on freely and without any more effort than on an air line. The introduction of an annunciator drop into the circuit made no difference. A test for insulation showed 400,000 ohms for the distance and a static capacity of 1·4 microfarad. A week later the same wires were used in the same manner with less satisfactory results. The weather was dry and warm. It was found that counting on one could be distinctly followed on the other, and *vice versâ*. The cross talk from the other wires was very noticeable, but not of sufficient volume to disturb the user. Conversation at a distance of eight inches from a fairly adjusted transmitter was indistinct and muffled. With the lips close to the transmitter, and by speaking in the usual tone of voice, the results were fairly satisfactory. This was particularly true when an air line of one and a-half mile was added. The measurements made after the test showed the insulation to be 4 megohms for the distance, against ·4 of a megohm on the previous test, and 1·05 microfarad capacity against 1·4. By opening one of the wires at both ends, so that all connection with the earth was removed, conversation could be freely carried on between three parties who were looped in. The first one was 5,000ft. from the open end of the cable, and the other 12,000ft. The only difference noted by the intermediate parties in the working of the wires with the ends open was that the cross talk was much heavier than with the grounds on. The second test indicates conclusively that we have used up all of our margin and that a slight addition to the length of the cables will make the connection of no commercial value. In fact, in ordinary dry, clear weather, conversation is only carried on by frequent repetitions and considerable discomfort. The nine cables included in this test are all in good condition, and with the exception of a few pieces of air cable, are new. On the above circuit there are sixteen terminals in use, but in all cases, except in exchange offices, the cable wires of one cable were connected with those of another at the terminals with kerite or okonite wire, so that the insulation was good at these points. The experience of four years has proved the fallacy of the practice of requiring the manufacturers to furnish a cable showing an insulation of from 300 to 800 megohms per mile. While this insulation can be secured immediately upon the completion of a cable, it is utterly impossible to maintain it. Nor is it desirable to maintain it, for the reason that cross talk is greater on a cable with a "fancy" insulation than in one of a megohm. Subscribers always complain of cross talk when their wires are put into a new cable, but after a few months we hear no more about it. This is not so much because they have become accustomed to the cross talk as it is that with the lowering of the insulation the cross talk is decreased. A better specification would be one megohm per mile and not more than five, and a guarantee from the manufacturer that this insulation will hold up for ten years. Such an insulation exceeds anything that we are able to get on air lines. In a recent test nine wires showed each an insulation of 5·3 megohms. Rain began to fall, and it ten minutes the insulation had fallen off to 3·2, and no doubt went lower. This illustrates the extreme sensitiveness of a high insulation to moisture, and indicates clearly that where there is a large number of cables in use the conditions are constantly varying, and nothing like uniformity in the working of the wires can be expected or secured.

ON JOINING LEAD-COVERED CABLES.

BY MR. PATTERSON.

The only thing to look out for in making a joint in a lead-covered cable is to keep out moisture. The ends of the cable, after the cable is made, should always be sorted out. Then after the cable is drawn into a conduit, the end of the pipe is cut off and the pipe removed from the core for a distance back corresponding to the size of the cable. For a 100-wire cable we would want to strip about 18 or 24 inches on each end. On the new style of cables arranged for metallic circuit each pair of conductors are twisted together and served with a single splint of cotton. The serving around the two wires will hold them in place until the man who is doing the splicing deliberately removes it. One is covered with white cotton and one with red and white—some colour that can be easily distinguished. The two wires are brought together, and the way we generally make a splice, and the best way, I think, is to strip the wires for an inch and a-half, bring them together, and instead of making a long splice, bend them up and then twist the ends together. That will leave the wire running through and the two ends twisted together standing at right angles to it. A cotton sleeve is drawn over it. This sleeve is like the outer braiding of office wire. After all the wires are spliced in that way they should receive a bath in very hot paraffin, poured on while they are laid out loosely to remove moisture, which they may gather from the atmosphere and from the hands of the men. Then the core should be covered and brought down to a compact size, that the lead sleeve will slip back over it. After that sleeve is on it should receive another paraffin bath. After the work is all done it is well to take a torch or something of the kind and pass it along underneath the cable and melt the insulation for a distance of one or two feet each side, so as to put on a pressure and test the joints; if there is any flaw it will show itself by the paraffin oozing when the pressure is put on. Occasionally, in underground work, it is not convenient to make a sleeved pipe. In that case we turn both ends of the cable up and bring them out through the top and have a brass casting in the form of an inverted Y. The two branches of the Y are of such size that the cable pipe will slip into them, and the main outlet is large enough to make the splice. The wires are brought up through it and spliced together, and the opening covered by a cap. After the work is done, that Y is dropped down into the hole and lifted. That removes the necessity of doing the work in the manhole. It is lifted up to the level of the street, and the man sits on the edge with his feet inside and works on it.

COMPANIES' MEETINGS & REPORTS.

The Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-eighth ordinary general meeting of this Company was held on Wednesday, 26th October, at Winchester House, 50, Old Broad-street, Mr. John Pender in the chair.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed and signed by the Chairman as correct. The report and accounts were taken as read.

The CHAIRMAN: I will, with your permission, now give you a few details as to the last half year's working. The gross receipts for the half year were £219,201, against £224,843 for the corresponding period of 1886, or a decrease of £5,642. This result, however, is not unsatisfactory having regard to the fact that in the corresponding period the reduced tariffs had not come into operation. The reductions agreed to at Berlin were, however, based on the figures of 1884 and 1885, which were the best years we have ever had, and although we shall this year carry a larger number of words than in 1884, we shall have only made up about £18,000 of the loss of £50,000 per annum, which was estimated from the reduced tariffs, leaving over £30,000 still to be recouped. As the traffic is increasing this loss will doubtless be made up in course of time; but our experience shows that the traffic does not respond so readily as the advocates of low tariffs would have us believe. The expenses for the half year were £76,241, against £81,775 for the corresponding period of 1886, showing a decrease of £5,534, which is due to our having disposed of the "Agnes," and having consequently had during the past half year only two maintenance ships, against three in the corresponding period of 1886. The net revenue for the half year was £97,662, against £97,480 for the corresponding period of 1886, showing an increase of £182. One quarterly interim dividend of 1½ per cent. has been paid during the half year, and another of like amount was distributed on the 15th inst., leaving £35,162 to be carried forward to the current half year, at the end of which the question of bonus distribution will be dealt with. I have during the last week, since the report was issued, received six letters from shareholders on the subject of the printed accounts, three of them having reference to the non-payment of a bonus for the half year. It was, however, always understood that any bonus that might be declared should be paid at the end of the year after having ascertained the result of the year's operations. We were, however, at one time urged by some of our shareholders—in 1884 or 1885 I think it was—to make the distribution half-yearly, which we did for several years, but after the reduction that we had to submit to at Berlin we thought it was more desirable to postpone it till the end of the year. No doubt at the end of the current year we shall be able to pay a portion of it at all events, and thus redeem our promise as we did in previous years. There have been no serious interruptions to our system during the past half year, although numerous repairs have been effected, and all the sections, excepting the Tonquin-Hong Kong cable, which is at present undergoing repair, are now in good working order. Since the close of the half year under review a further portion of the Singapore-Saigon section, which is the only main cable unduplicated, has been renewed with brass-ribboned cable to the length of 174 nautical miles, leaving about 150 nautical miles to be renewed. This will, in all probability, be completed during the current half year, in which case the cost of the operation will be shown in the next published accounts.

This question of the renewal of cables, and the damage effected by the teredo is a very important one. We had for many years constant cause for repairs by the action of that insect, but we set our brains to work, and the result was that we hit upon a plan which has greatly obviated the difficulty, by using brass-ribboned cable. The following statistics will show the value of brass-ribboned cables in teredo-infested waters:—Before the Singapore-Batavia cable was renewed in 1881 no less than 194 faults were removed in 11 years, or on an average 18 a year; whereas, during the last six years only four breaks have occurred, and these have been entirely due to ships' anchors. On the Banjoewangie-Darwin cable 67 faults occurred before it was partially renewed in 1884, since which time not one fault has occurred in the brass-ribboned portion. The same remark applies to the Singapore-Saigon cable, which was partially renewed in 1885, although forty-nine faults had previously occurred. Consequently our experience, extending over a period of nearly seven years, clearly shows that

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the brass-ribboned cable has successfully resisted the attacks of the teredo, from which we sustained so much damage until we adopted this valuable form of protection. The Company's new shore cable establishment at Singapore, in place of the hulk, "Southern Ocean," has been completed, and the tanks and machinery from the latter were transferred to the shore establishment before the hulk was sold by public auction.

At the last meeting I went fully into the details of our relations with the Australian colonies and New Zealand, and have now only to state that during the last six months, since the return of the delegates to their respective homes and Governments, nothing has been done. At the end of next month, I believe, there is to be a conference at Adelaide to consider the question of cheaper postal rates and lower telegraph rates between the mother country and the colonies; and until the Directors hear of the decision arrived at their policy will be to leave things alone. Since the last meeting of the Company a fresh Parliament has been elected in New Zealand, and the Government from whom the Company had differed were out of power. As soon as their successors have had a little time to settle down the Directors will resume the correspondence, with, I hope, a fair prospect of success. The Company have been in negotiation with the Chinese Government during the half year, and have tried to show that Government that submarine telegraphs were a great necessity for China, and the Chinese Government endeavoured to prove that land lines would beat the submarine system. The result has been that an understanding has been come to by which both interests will be properly protected. The points of the agreement have been settled, and it simply awaits the approval of the Chinese Foreign Office; and when that matter is settled I hope that for the next sixteen years we shall be able to look at the growth in the China trade without any fear of undue competition. I may mention that nearly the whole of our system is duplicated—I might almost say, triplicated—so that we are in every way in an efficient condition for the conduct of our business. Our relations with the Imperial and Colonial Governments are of the most friendly nature. The other day the Imperial Government laid down a cable to Port Hamilton, which they afterwards found they did not require, and we took the opportunity to take it off their hands at such a price as would enable us to utilise it with advantage. I think that I have gone over all the points that it is necessary to call your attention to, and I will finish by saying that our relations with all foreign Governments are very satisfactory and our revenue is increasing, and I hope by the time we meet you six months hence we shall be able to show that there has been considerable progress for the half year, and that we shall be able to resume the payment of the bonus. I will conclude by formally moving the adoption of the report and accounts.

The Most Hon. the Marquis of TWEEDDALE seconded the motion, which was carried unanimously.

A vote of thanks was afterwards passed to the Chairman and Directors, and the proceedings terminated.

Hammond Electric Light and Power Supply Company (Limited) (in Liquidation).

An extraordinary general meeting of this Company was held at Winchester House, Old Broad-street, yesterday (Thursday), under the presidency of Mr. William Theobald (the liquidator).

The SOLICITOR having read the notice convening the meeting,

The CHAIRMAN, in the course of his remarks, said: I feel that before I go to the report I should refer to the circular issued in April last, stating that we should probably call a meeting in the following June. Soon after that circular was issued I found, on looking into the matters outstanding, that they were so few and of such little value that if I deferred calling the shareholders together for a little while, I should be able to place before you the final accounts, and that I am able to do to-day. I have the pleasure of presenting the following report upon my duties as liquidator, which I venture to think will reveal a more satisfactory result than was at one time anticipated. On the 10th of June, 1885, I was appointed by the Chancery Division of the High Court of Justice provisional liquidator of your Company, with power to carry on the business, so far as was necessary for carrying out and completing existing contracts, and to pay wages and other charges. On the seventeenth day of the same month, at an extraordinary general meeting of the members it was resolved that the company should be wound up voluntarily, and I was appointed liquidator. The following shareholders were at the same time appointed a consulting and advising committee, viz.:—Messrs. E. H. Brown, A. M'Alister, and F. W. Reynolds. Immediately on taking possession of the assets and undertakings of the Company, including as they did important uncompleted contracts, it became apparent that many of them were of a very special character, their advantageous realisation demanding personal and most careful consideration, and I have to acknowledge the valuable assistance which was afforded me at this time by the advising committee. Valuable assistance was also rendered from time to time throughout the proceedings by Mr. Robert Hammond, which has been of substantial service to the liquidation. The peculiar nature of the difficulties attending the realisation of some of the assets may be best exhibited by a few examples [which he proceeded to give]. A lighting station at Brighton had been worked for some time, but was in a very incomplete state, and under the conditions of the lease certain of the engines used for driving the dynamos had to be removed. Although there seemed every probability that by expenditure of additional capital the lighting station might be placed on a profitable basis, it was doubtful if at that time it was paying expenses. A contract for management for a term of years had been entered into with the Eastbourne Electric Light Company (Limited), under which the Hammond Company were to bear all losses or take the profits, if any, on the working; they were also to provide the requisite capital for extension purposes, and to receive payment in debentures of the Eastbourne Company. A similar contract had also been entered into with the Hastings and St. Leonards-on-Sea Electric Light Company (Limited). Under the two last-mentioned contracts the Hammond Company had become entitled to debentures of the Eastbourne Company for about £7,050, and of the Hastings and St. Leonards Company for about £3,300. In the case of the Eastbourne Company the debentures, jointly with others to the extent of £500, formed a first charge upon the assets of the Company; but in the case of the Hastings Company the debentures only ranked after a charge for £4,000 given to the bankers. Neither of the above companies were paying expenses; and after careful consideration it was decided to risk the refusal of supplies to the Hastings Company (fortunately without causing a stoppage of their business), but to carry on the Eastbourne contract for a time in the hope of obtaining a purchaser for the debentures, who would also undertake to perform the contract. With this object in view the liquidator made overtures to the Anglo-American Brush, the Edison and Swan, and other electric light companies. Protracted negotiations and correspondence also were carried on with the representatives of all the various interests concerned, but without satisfactory result; and after long and tedious efforts to sell by private treaty it was determined to offer for sale by public tender not only the Brighton Lighting Station, the Hammond Company's interests in the Hastings and St. Leonards-on-Sea Electric Light Company, and the Eastbourne Electric Light Company, but also what remained of the hiring installations in other parts of the country. Advantage was taken of the issue of a circular by the Consulting Committee on the 16th September, 1885, to forward a copy of the advertisement of this sale to every shareholder on the register. Offers were received for each of the properties mentioned, some of which were immediately accepted, but in other instances improved prices were obtained by subsequent negotiations. The issue of the tender forms and the acceptance of each offer were made with the approval and under the direction of the Court. I found it impossible to arrange any scheme for the reconstruction of the Company; and as inquiries are still occasionally made on the subject, I cannot do better than quote from the circular of the committee above referred to, in which they say:—"Since you appointed us to confer with your liquidator, we have carefully considered the possibility of a resuscitation of your Company, and we regret that we are unable to recommend such a course. The large amount of liabilities and claims, about £20,000, and the peculiar nature of the assets, would necessitate an immediate subscription of considerable capital, which we do not feel justified in asking the shareholders to find." They added—"We fear the prospect of any return being made to the shareholders is extremely doubtful." Since issuing this circular in September, 1885, the committee have taken no part in the management of the liquidation, feeling that the shareholders were not likely to obtain any benefit from their labours, and having at the meeting convened by the above circular resigned their position. Another of the undertakings in connection with, and, in fact, forming part of the Hammond Company, which at one time seemed likely to involve many troublesome claims for uncompleted contracts, was the Electrical College, in Red Lion-square. Having explained the steps taken in this matter, he added:—All the claims from the parents and guardians of the students, which at one time seemed inevitable, were avoided. Not one claim was sustained, and I believe general satisfaction was given. In conducting the liquidation it was often difficult to decide how far it was advisable to carry out contracts for work on hand and hiring contracts, and whether less loss would be incurred by breach of the contract than by completing it. The labour of realising the estate and in settling the claims has been much heavier than was at first anticipated. It is a source of pleasure to me, therefore, to be able to report that, whereas at one time it seemed doubtful if even the creditors would be paid in full, I am able to report to-day that they have all been paid, and it is proposed to make a return of 3s. per share to the shareholders. When the property came into the hands of the liquidator a large amount of the stock was in an unfinished condition. After careful consideration it was determined to complete as many dynamos as possible before offering them for sale. Several offers were received for part of the plant and stock by private treaty, but the difficulty of fixing prices being considerable, and some of the offers received being absurdly small, it was decided, with the full concurrence of the committee, that all should be offered by public auction, excepting sales at current prices. In accordance with that decision, the whole of the plant, stock, and apparatus at the factory in Appold-street, at the stores in Bermondsey-street, at the lamp factory in Bermondsey, and at the Electrical College in Red Lion-square, were offered for sale at public auction, the sale occupying seven days. The amount realised, after deducting the heavy expenses and the auctioneer's charges, was £11,604. 4s. The wisdom of the policy adopted, and of making so much of the sale as was done by extended advertising, was then fully manifested. The Anglo-American Brush Company's concessions and the Ferranti patents were offered at the auction sale, but no bids were made. Sales, however, have been effected subsequently at low prices. Under an agreement with Messrs. Donnithorne and Liardet, £5,695 had been deposited with Messrs. Hoare, the bankers, as a guarantee fund in connection with a contract. After referring to the legal proceedings between Messrs. Donnithorne and Liardet and the Company, in connection with this contract, he continued: Early in August, 1885, the action was dismissed with costs, and the deposit, with interest, amounting in all to £6,099. 13s. 9d., was ordered to be paid to me as liquidator. This was received on 19th November, 1885. In addition to the ordinary creditors for goods, &c., various claims arose out of royalty and other contracts; also heavy claims and complications arose in connection with the various leases held by the Company. I was enabled to settle all of these claims on favourable terms, and to get

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the Company relieved of the claims on the leases. The claims of the debenture holders, which were carrying interest at the rate of 7 per cent. per annum, were discharged under an order of the Court in January, 1886, thus stopping interest at that early date. The list of the other creditors having been settled by the Court, notice of payment in full was given in May, 1886, and all have been discharged. The provisional cash statement herewith presented exhibits the amount obtained for the various properties of the Company in a summary form only, but I shall be happy to supply such details as the shareholders may desire. The result of the liquidation shows that after paying the debenture holders and creditors' claims, amounting to £15,246, there remains a balance in hand of £8,583. There are, however, a few paper assets still to be dealt with before the liquidation can be finally closed. In conclusion, it only remains for me to remind you that when I was first appointed it was not expected that the work of the liquidation would have entailed such unremitting and personal labour, or that it would turn out so favourably to the shareholders as it has done. In view of this, your liquidator was induced to accept a fee of 600 guineas. The result of the liquidation, however, entitles him, according to the scale fixed by the Court of Chancery, to a much higher rate of remuneration, which would, no doubt, be allowed upon application to the Court, but it would be some satisfaction to the liquidator if the meeting were to pass a resolution which would certify their appreciation of his services. It is upon the official basis of remuneration, as allowed by the Court, that the accounts now about to be laid before the meeting are made out, showing a balance of £8,583. 10s. 11d, and the liquidator proposes forthwith to make a return to the shareholders of 3s. per share, which will absorb £8,401. 1s. 0d, and thus practically close the liquidation.

After a few remarks from Mr. EDENSOR,

Mr. INCE warmly commended Mr. Theobald for the manner in which that gentleman had carried out the liquidation, and he proposed a resolution, increasing the personal remuneration of Mr. Theobald to 900 guineas, on the condition that 3s. a share was returned to the shareholders.

Mr. A. M'ALISTER said that the meeting must first deal with the report and accounts.

Mr. INCE said that in point of order Mr. M'Alister was right, and he would therefore propose the following resolution first—"Resolved that the report of the liquidator and the accounts of the liquidation be, and the same are hereby, received and adopted, and that, in view of the liquidator's report, this meeting is of opinion that the whole of the outstanding assets are irrecoverable and valueless, with the exception of the iron safe and office furniture, and that the liquidator be, and he is hereby, instructed to refrain from any further effort, and from incurring any further expense in connection with attempts to dispose of such outstanding assets, and that upon the completion of the winding up the said iron safe be retained by the liquidator for the purpose of preserving until such time as the Court sees fit the books and documents of the Company."

Mr. A. M'ALISTER seconded the resolutions. He as one of the Committee of Inspection had had the opportunity of seeing the way in which Mr. Theobald had worked, and the result was that, instead of receiving nothing, the shareholders would have 3s. a share. Instead of spinning out the liquidation for years, Mr. Theobald had worked to close it as soon as possible.

Mr. F. W. REYNOLDS said that the committee had found that it would be hopeless under the circumstances to reconstruct the Company. Mr. Theobald had done everything he possibly could for the shareholders. Possibly the Company came into existence rather too soon; but he believed that all present felt that there was a great future for electricity, not only in regard to lighting, but also as a motive power.

The CHAIRMAN, in reply to a question, said that the money was all in hand, and he proposed to distribute it as soon as the circular could be sent out.

The SOLICITOR then read the resolutions, which were separately agreed to *nem. con.*

The meeting then terminated.

The Brazilian Submarine Telegraph Company.

The following is the report of the Directors for the half-year ended 30th June, 1887, to be submitted to the twenty-eighth ordinary general meeting to be held on 2nd November, at Winchester House, Old Broad-street, E.C., at 12 noon :—

The revenue for this period amounted to £100,876. 7s. 6d., and the working expenses to £13,262. 2s. 10d. After providing £14,205 for debenture interest and sinking funds, and £2,004. 17s. 6d. for income-tax, there remains a balance of £71,404. 7s. 2d.; to this is added £7,528. 5s. 1d. brought forward from 31st December last, making a total of £78,932. 12s. 3d. A quarterly interim dividend amounting to £19,500 has been paid, and £25,000 transferred to the reserve fund, leaving a balance of £34,432. 12s. 3d. The directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total dividend of six per cent. for the year, and also the payment of a bonus of 2s. per share, both free of income-tax, which together will amount to £32,500, being a distribution in the aggregate of 7 per cent. for the past year, leaving a balance of £1,932. 12s. 3d. to be carried forward. On the 30th July last the sum of £37,100 was transferred from the sinking fund to pay off the 371 bonds of the 1884 issue, drawn for redemption in April last. This repayment reduces the debenture debt to £187,900. The various sections of the Company's line are in good working order.

Sir James Anderson and the Hon. W. St. John F. Brodrick, M.P., retire by rotation at this meeting, and, being eligible for re-election as Directors, offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 21st October amounted to £4,270.

CENTRAL AND SOUTH AMERICAN TELEGRAPH COMPANY.—This company has declared a quarterly dividend of 1½ per cent., leaving a sum of $12,500 to be carried forward.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company give notice that the coupon on their Five per Cent. Manila Debentures (1880 issue) due on the 1st November proximo, will be payable on and after that date on presentation of the same at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons must be left three clear days for examination.

INDO-EUROPEAN TELEGRAPH COMPANY.—The directors of this company have declared an interim dividend for the half year ended the 30th June last at the rate of 5 per cent. per annum, being the same as for the first half of 1886.

MEXICAN TELEGRAPH COMPANY.—The Mexican Telegraph Company has declared a quarterly dividend of 2½ per cent., leaving a surplus carried forward of $11,000.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 21st October, 1887, were £3,316, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—At a meeting of the directors of this company, held on the 26th inst., it was decided to recommend to the shareholders at the approaching meeting that a dividend of 9s. per share be declared on account of arrears of dividend on the First Preference Shares.

PERSONAL.—Mr. J. H. Cundall, M.I.C.E, has taken offices at 121, Cannon-street, E.C., and commenced business as a Consulting Electrical Engineer. Many electricians will recollect that Mr. Cundall organised and superintended the lighting of the Indian and Colonial Exhibition, and the success which attended his efforts upon that occasion should go a long way towards assuring him ample support in his new career.

——— Mr. Arthur Morley, of Rodliffe-street, Islington, trading as The Vulcan Manufacturing Company, informs us that Mr. Wilson has retired from the business.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 26.		BUSINESS DONE WEEK ENDING OCT. 26. Highest.		Lowest.	
Anglo-American	33½,	39½	..... 39½	.....	37½	
Do. Preferred	64,	65	..... 65½	.....	61½	
Do. Deferred	14½,	15½	 15	.....	13½	
Brazilian Submarine	11¼,	11½	..... 11½	.....	11¼	
Cuba	11⅜,	12½	..... 11½	.....	—	
Do. Preference	18,	19	..... —	.....	—	
Direct Spanish	2½,	3½	..... 2½	.....	— xd.	
Do. Preference	8,	9	..... —	.....	— xd.	
Direct United States Cable	9½,	9¾	..... 9½	.....	8¾xd.	
Eastern Telegraph	11,	11½	..... 11 3-16	.....	11 xd.	
Do. 6 per Cent. Preference	14,	14½	..... 14 7-16	.....	14 xd.	
Do. 5 per Cent. Debentures, 1899	106,	109	..... —	.....	—	
Eastern Extension	11½,	11⅞	..... 11⅞	.....	11½xd.	
German Union	10½,	11	..... —	.....	—	
Globe Telegraph and Trust	5⅝,	5⅞	..... 5 9-16	.....	5 7-16xd.	
Do. Preference	13½,	13⅝	..... 13⅝	.....	13 1 16xd.	
Great Northern	13½,	14	..... —	.....	—	
Indo-European	36,	38	..... —	.....	—	
Reuter's	8,	8½	 8	.....	— xd.	
Submarine	170,	180	..... —	.....	—	
West India and Panama	6,	7	..... —	.....	—	
Do. 1st Preference	9½,	9⅞	..... —	.....	—	
Western Brazilian	7⅝,	7⅞	..... 7¾	.....	7⅜xd.	
Western Union 7 per Cent. 1st Mortgage	120,	125	..... —	.....	—	
Do. 6 per Cent. Sterling Bonds	101,	104	..... —	.....	—	

TELEPHONES.

Consolid. Telephone and Maintenance	⅝,	¾	.....	—	.....	—
Oriental	½,	⅝	.....	—	.....	—
United Telephone	11,	11½	.....	11⅜	.....	11 3-16
United River Plate	4¾,	5¼	.....	—	.....	— xd.

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¼,	2⅜	.....	—	.....	—
Do. (fully paid)	3,	4	.....	—	.....	—
Swan	1⅝,	1⅞	.....	1⅝	.....	—
Maxim Weston	3-16,	5-16	.....	—	.....	—

MISCELLANEOUS.

Telegraph Construction	37,	38	.....	37½	.....	36¾
India Rubber, Gutta Percha, and Telegraph Works	20½,	21½	.....	21¼	.....	20½

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NOTES.

BRUSSELS.—A considerable length of the phosphor bronze telephone line between Paris and Brussels has been torn down by the recent gales.

LONDONDERRY.—The Corporation of Londonderry are inviting tenders for the supply of electric light. Particulars may be found in another column.

THE CARLTON CLUB.—The Carlton Club, which was re-opened this week, is now lit by Ferranti transformers, from the Grosvenor Gallery Central Station.

THE WAR OF CABLE RATES.—It is believed in cable circles that the visit of Mr. Jay Gould to this country will lead to an arrangement between the rival companies.

THE BRIGHTON ELECTRIC RAILWAY.—We regret to learn, at the moment of going to press, that the severe south-westerly gale of Thursday has caused very serious damage to Magnus Volk's Electric Railway.

TWO MEN KILLED BY LIGHTNING.—On Sunday night at Carahboge, between Killorglin and Glenbeigh, a farmer named Walsh was, during a storm, tying a cow up in a shed, his eldest son standing some yards off, when a flash of lightning came, and the two men and the cow were struck dead.

ELECTRIC TRACTION AT RICHMOND. — Messrs. Christi, James and Co.—who, we understand, are acting in this matter as the agents of a French firm—have been making experiments during the present week with a tramcar propelled by secondary batteries on the line between Kew Bridge and Richmond. We shall probably be in a position to give further details next week.

APPOINTMENT.—Mr. Samuel Vyle, of Glasgow, has received the appointment of Electrician to the Post Office of British Guiana, an office which involves the responsibility of the technical charge of the Government land lines and cables of that colony. Mr. Vyle will leave Glasgow for British Guiana about the 26th inst., and his departure will be regretted by a numerous circle of friends.

DISTURBED IRELAND.—The police authorities have issued notices throughout West Clare in reference to the cutting down of the telegraph wires between Kilrush and Ennis last Sunday. It is stated that in future where such outrages are attempted a police hut will be erected on the scene of the occurrence, and the parish will be taxed with the cost of the constabulary stationed at the hut.

HALIFAX (N.S.).—It is stated that the cable steamer "Britannia" is about to move the shore ends of the Direct United States Company's cables from Tor Bay to Halifax, which is ninety miles further South. The "Britannia" has on board the necessary lengths of new cable. The general tendency appears now to be in favour of bringing cables ashore as close as possible to the most important towns of the coast-line, instead of landing them on uninhabited spots.

TELEGRAPH STORES REQUIRED.—The directors of the South Indian Railway Company advertise for tenders for telegraph stores. Specifications (price 10s.) may be obtained from the Managing Director, 55, Gracechurch-street, E.C., and tenders must be returned by November 15.—The Cheshire Lines Committee also advertise for tenders for telegraph stores, including wire and instruments. Specifications may be obtained from Mr. W. H. Legge, storekeeper, Warrington, and tenders must be returned by December 3.

ELECTRIC WELDING.—Messrs. Laing, Wharton and Down write us as follows:—"We notice in your issue of the 21st ult. a notice relating to 'Electric Welding in Germany,' and in this connection we have to say that we are informed that active measures are being taken in that country to organise a strong syndicate to put in operation Prof. Elihu Thompson's electric welding apparatus, on which he has very valid patents, and power is now being placed for the working of welding plant, which is now on the way and will soon be in practical use."

BLACKPOOL.—The directors of the Blackpool Electric Tramcar Company held a field day on Friday last. The promenade was hung with arc lights, in which eight different systems were represented, and the tramcars themselves, as the local reporter says, "were brilliantly illuminated by the same agency." Afterwards there was a dinner, at which the Mayor of Blackpool presided, and amongst other distinguished guests there were present Mr. Alexander Siemens, the Mayors of Manchester and Halifax, and Mr. J. Oddey, an ex-mayor of Ballarat.

TUESDAY'S GALE.—Notwithstanding the violence of the gale which swept across the greater portion of England on Tuesday last, comparatively little damage seems to have been done to telegraph and telephone plant, although other kinds of property suffered severely. At Blackburn, where it was exceptionally furious, some of the wires were blown down, interrupting communication between the town and other places for about two hours. Beyond these and the destruction of one or two electric lamps at the Newcastle Exhibition no other casualties in electrical property have been reported.

THE CHANNEL CABLES.—It is stated that the Chamber of Commerce at Havre has addressed to the French Government a protest against the renewal of the monopoly to the Submarine Telegraph Company. Protests of a similar character are likely to come from Paris, Bordeaux, Rheims, and other towns. It is a little surprising that no movement has yet been made on this side of the Channel, but probably there is a feeling that the danger of the renewal of the monopoly is too remote to give cause for alarm. Still, it would be as well for those chiefly interested not to lose sight of the matter until the question has been finally set at rest.

THE LIGHTING OF THE MILE END INFIRMARY.—The Mile End Board of Guardians has obtained a report on the cost of providing their infirmary with electric light. It appears that motive power is already available in the shape of an engine employed at present for chopping wood, and hence a considerable economy is expected. The present cost of gas lighting is £356, and the estimated expenditure for electric light is £200 per annum. While it would be rash to express any opinion on these figures without knowing something more of the conditions, on the surface it is difficult to understand how the saving of £156 is to be effected, even with the engine thrown in. We make this observation in the interests of all concerned.

THE SOCIETY OF ENGINEERS.—At the next ordinary meeting of this society, to be held on Monday, 7th November, at 7:30 p.m., at the Westminster Town Hall, a paper will be read on "Primary Batteries for Illuminating Purposes," by Mr. Perry F. Nursey, past president, of which the following is a synopsis:—"Introduction. A wide field open for primary batteries. Their principles and history outlined. Descriptions of batteries for special purposes, and batteries for general lighting, including those of Holmes and Burke, Ross, Coad,

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Lalande, Skrivanow, Upward, Pollak, Newton, D'Humy, and Friedlaender; and the 'Regent,' the 'Union,' and the 'Eclipse' batteries. Conclusions." Several of these batteries will be exhibited at the meeting.

THE INSTITUTION OF CIVIL ENGINEERS.—The ordinary meetings of the Institute of Civil Engineers will be resumed on Tuesday, the 8th November, and be continued weekly till the end of May. At the opening of the session Mr. Geo. B. Bruce (president) will deliver his address. On subsequent occasions the following papers, amongst others, are to be read with a view to discussion:—"Accidents in Mines," Part II., by Sir Frederick Abel, C.B., F.R.S.; "Electrical Tramways: the Bessbrook and Newry Tramway," by Dr. E. Hopkinson, M.A.; "Manganese in its Application to Metallurgy," and "Some Novel Properties of Iron and Manganese," by R. A. Hadfield. The supplemental meetings of students have been appointed to commence on Friday, November 18th, and to take place at nearly fortnightly intervals.

TELEPHONES FOR SICK ROOMS.—A correspondent of a daily journal mentions a recent application of telephones to and from the bed rooms of scarlet fever patients. A telephone from the sick room to the rest of the house is a great comfort in any case, but in all cases of infectious disease is an immense alleviation of the patient's lot. The cost of putting one up is comparatively trifling, and the gain to the prisoner is important. Before it is up his bed room is his world, and a very thinly populated world too; for often enough the only members of society he sees are the doctor and the nurse, and the dreary hours pass by monotonous and solitary. After the telephone is fixed, adds the enthusiastic correspondent, "he can talk to his friends, he can listen to a novel, he can play chess or cards, he has a score of diversions; and all this without the slightest risk of infection."

RUMOURS.—We are more or less credibly informed that preparations are now being made for the invasion of the City of London by alternating currents on a prodigious scale. At Deptford (another account says at Millwall) several acres of ground have already been cleared for the erection of the (ex)-central station. Five marine engines, each of 4,000 horse-power (another account insists, however, that there are only four engines, each of 5,000 horse-power), are to provide motive power. An unknown number of dynamos, each with 40-feet armatures, are to supply current at 10,000 volts. Perhaps we had better say no more for the present.—It is stated that the Water Primary Battery Company have secured on a long lease a site in York-street, Westminster, "where a large central station will be erected for lighting by electricity the mansions and buildings in Victoria street, Westminster, and in Pimlico." Seeing that the neighbourhood of Victoria-street is the quarter wherein electricians and engineers most do congregate, this resolve of the W. P. B. Co. should perhaps be regarded as proof of simple good faith.

SECONDARY BATTERIES AT BRUSSELS.—We learn from the *Bulletin Internationale de l'Electricité* that the trials of the Tamine accumulator which have been carried on for some months by the Société Industrielle d'Electricité have not resulted satisfactorily, and their manufacture has been suspended. It will be remembered that the Tamine is a zinc-lead cell, and it appears that the difference in the density of the mixed solution of lead and zinc salt has a tendency to put a stop to the chemical action in the upper part of the plates. The evil then grows at an accelerated pace. There was also discovered a tendency to run down on open circuit, which is, we believe, a discouraging feature of most of the lead-zinc combinations hitherto tried. The next cell on the list appears to be the "Tudor," which is at present in the stage of great expectations. The Tudor cell is said to have had a long trial at Luxembourg, and to have given excellent results, particularly as regards durability. It is of the Planté type, and appears to rely upon a special form of grid for its peculiar merits. The Tudor cell is now to be tried in Brussels.

BIRMINGHAM.—An installation which has just been completed by Messrs. Chamberlain and Hookham in this city affords an undeniable instance of an economical victory over coal-gas. Such instances are not so plentiful that we can afford to overlook any one. The installation in question has been erected for the Linde British Refrigerating and Ice Company, who occupy premises in the basement of the Birmingham Fish Market, so that artificial light is required all day long. But in addition to this the Linde Company carry on their work night and day continuously, so that every lamp has the chance of making about 8,600 hours per annum. This alone would probably bring down the relative cost of electricity compared with gas at, say, 2s. 6d., to something like level terms, but in addition to this it happened that motive power was already available, so that friction clutches and countershaft alone remained to be provided. Messrs. Chamberlain and Hookham assure us that the total annual charge will not, under these circumstances, exceed *one-fourth* that for gas at 2s. 2d. per 1,000 cubic feet. The installation is not a large one. There are two Hookham dynamos, one for 12 55-volt 16 c.-p. lamps, and the other for 30 55-volt c.-p. lamps. At present only 25 lamps are hung.

BRUCE'S BALLOON SIGNALS IN BELGIUM.—On the 26th ult., some trials of Mr. E. Bruce's system of transmitting military signals at night took place at Antwerp, before General Pontus, the Belgian War Minister, and several distinguished officers of the Belgian army. Our readers will probably recollect that this arrangement (which has been adopted in our own army) consists merely of putting some incandescent lamps inside a small balloon which is allowed to float at a moderate height, and then flashing signals by means of a Morse key with carbon contacts. The system is so simple and practically certain in its operation that it scarcely needs any preliminary trial, and we need hardly say that the rehearsal at Antwerp gave perfect satisfaction to all concerned. The signals were easily read at a distance of 3,000 metres, but observers were also stationed on the cathedral tower at Mechlin, and on the church at Wilrysch—distant about twenty miles. Their reports had not been published, but owing to the fact that the balloon only attained a height of 100 metres, it was not thought probable that the signals could have been seen so far. We have little doubt that the arrangement will become common in the European armies. We may add that the batteries used on this occasion were supplied by the Electrical Power Storage Company.

ELECTRIC LOCOMOTIVES VERSUS AUTOMATIC CARS.—With regard to recent criticisms on the Elieson tram-car system, it is only fair to call attention to the fact, stated (or implied) in our article on October 21st, that the system does not rely exclusively upon the use of separate locomotives. It is true that the gearing requires a good deal of space, and probably the floor of an automatic car fitted with Elieson gear would have to be raised higher from the ground than an ordinary car. That is a point upon which we have no information at hand, but we do know that the Elieson Company proposed to stock the Manor Park line with automatic cars, and did not intend to build any more separate locomotives. We have

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always held that the separate locomotive is out of place on a tram line, and this view is, we know, shared both by the Elieson Company and by the Electric Traction Syndicate. But the fact is that in the preliminary stage the Elieson Company had no option. The tramway company, naturally and reasonably enough, said in effect, "Here are our cars; can you take them just as they are and draw them by electricity?" To this question it is evident that the only possibility of affirmative reply arises from the use of separate locomotives. If it were a question of stocking a new line we suppose that there would hardly be two opinions as to the proper choice.

PROF. GEORGE FORBES IN AMERICA.—As many of our readers will be aware, Prof. Forbes left England for America shortly after the close of the British Association meeting, mainly in order to exhibit his new meter at the American Institute of Electrical Engineers. The American public, however, takes so genuine and intelligent an interest in the practical applications of science that the advent of Prof. Forbes and his meter has created a stir far beyond the bounds of the purely electrical community. The Sunday issue of the New York *Sun* (October 16th) devotes over a column to the subject, and gives a rough woodcut of the instrument. The article has, in American fashion, three headlines, in type of various sizes, as follows:—"To Measure Electricity. An English Scientist Sets Up A Practical Meter. It Will Tell How Much Lightning Flows Over A Wire, And Tell It Not Only To The Producer But To The Consumer." After this introduction follows a sensible and well-written article describing the apparatus in detail. After the innings which American inventors have had on this side it should be a source of gratification, not only to Prof. Forbes's personal friends, but the entire British race, if the new meter comes into universal use in the States. In another column will be found a condensed report of the discussion which followed the reading of the paper at the Institute of Electrical Engineers.

CLOSING OF THE NEWCASTLE EXHIBITION.—The attendance on the closing day amounted to 54,716, raising the number of visitors for the season to over 2,092,000. Throughout the whole run of the Exhibition no short-circuit or other accident involving risk of fire occurred in the building in connection with the electric light, and the only occasion upon which any considerable number of lamps were extinguished occurred about a fortnight before the closing day, and this was an accident for which the electricians were in no way responsible. A small piece of packing blew out of one of the flange joints of the main steam pipe about 6 p.m., and the engineer in charge thought it advisable to shut off steam at the boiler until the joint was repaired. This involved the extinction of the principal lamps in the four main courts for nearly an hour; but the lights in the western annexe, one of the largest courts in the Exhibition, measuring 650ft. in length, all the lights in the central and north gardens and verandahs, the picture galleries and dining rooms, the offices, and main entrance, as well as a number of small lamps about the courts, remained unaffected, so that there was everywhere sufficient light to prevent accidents; and the portions of the Exhibition which remained fully lighted were far more than sufficient to accommodate the visitors. By about 7 p.m. everything had resumed its normal condition, and no one was inconvenienced by the accident except a jury, who were anxious to finish their work before closing time.

FOR "SAFETY" SAKE.—We feel that we owe some amends to a correspondent signing himself "Safety," whose letter of inquiry we recently inserted in our correspondence columns, and to whom as yet no reply has been given. "Safety" inquired whether it was true "in lighting a theatre by electric light" that "any time a wire was broken" an arc light would be set up between the broken ends which might easily cause a fire, and if so what precautions are of avail to prevent this. The *possibility* of a fire arising in this way is undeniable, but the *probability* of such an event is, or may easily be made, extremely remote. "Safety" will easily understand that this is the case if he will consider (1) that by far the greatest portion of the conductors employed in wiring buildings are composed of stranded cables made up of many smaller wires, which are therefore extremely difficult to break. In many cases the whole of the wiring is done with this kind of cable, and there is no reason why this should not always be the rule. (2) These cables are nearly all enclosed in special pipes or mouldings, and should never be required to support any strain, so that except in the event either of a structural accident to the building or of malicious design, the breaking of a cable is an almost impossible event. (3) Lastly, supposing such a thing to have occurred, even then an arc would not be set up, unless the severed ends of the cable remained quite close together, which is unlikely considering the force required to effect the break. "Safety" may rest assured that a network of gas pipes, with its threefold possibility of fire, poison, and explosion, is decidedly a more dangerous addition to a theatre than a network of electric conductors.

THEATRE LIGHTING.—The stars in their courses fight unweariedly for the suppression of gas in the theatres of London. Within seven days we have had two more hair-breadth escapes. The Canterbury Music Hall was actually on fire, and but for the gratifying fact that the behaviour both of the staff and of the audience was beyond all praise, a catastrophe would undoubtedly have ensued. At the Lyceum, the other evening, Capt. Shean (the second in command of the Metropolitan Fire Brigade) actually saw a piece of paper fall from the gallery, take fire in a naked gas flame and flutter into an empty box. We take it to be just as important (and far less harrowing) that the public attention should be fixed on incidents of this character as upon such horrors as the burning of the Opéra Comique or of the theatre at Exeter. That a certain amount of good has been effected by the recent agitation is undeniable, but very much remains yet to be done. In France the subject continues to receive great attention, and on the 21st ult. M. de Hérédia, the Minister of Public Works, attended a meeting of the Société des Ingénieurs in order to listen to several short descriptive papers on the use of electric light in theatres, followed by a debate on the whole question. During the proceedings M. Vernes, chief engineer of the Continental Edison Company, called particular attention to the fact that, owing to the high temperature of the gas flame, the cordage and draperies of the upper portion of the stage of a theatre lit by gas were always found to be in an almost desiccated condition, and this, he had no doubt, would account for the extraordinary speed of such conflagrations. M. Vernes then went on to deal with the precautions necessary to be taken in the wiring and machine rooms, and was followed with great attention by the engineers and their distinguished guest.

LONG RUNS OF ENGINES AND DYNAMOS.—A Mr. H. M. Kinsley, proprietor of a restaurant in Chicago, states that an Edison 250-light dynamo, driven by an Armington-Sims engine in his possession, started running on July 24th at 9 a.m., and stopped on September 25th at 10:30 a.m., making a run of 63 days 1½ hours, or 1,513½ hours. At 330 revolutions per minute this is equal to 29,967,300 revolutions, and at the end of this time a little keying up was all that was required. The load is said to have varied between 75 and 275 lamps.

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This is not, however, the longest continuous run on record. So far as we are aware that honour still belongs to the pair of Edison machines which in 1884 ran without stopping for 97 days in the Post Office at Boston. It would be interesting to know what type of engines was employed in the latter instance. Third on the list comes, we believe, a Kapp machine, which was reported last year to have run continuously for 26 days and nights on board H.M.S. "Devastation." Machines running on board ship are certainly handicapped heavily, so that this probably runs the Chicago performance very closely for second place. Then there is the Edison-Hopkinson machine, built by Mather and Platt, which was shown at the Inventions Exhibiton, and had done a 14 days' continuous run. We believe that the E. P. S. Co. on one occasion ran a Brush machine continuously for about six weeks. Finally, we may mention a run of nearly 17 days made in New York in 1883—again by an Edison machine. Doubtless there are many machines whose performances have not been chronicled in type which have done as well, and there are makers who would be prepared to guarantee to beat the record if it were worth while. In fact, as soon as a machine has attained its maximum temperature throughout a prolonged run does not really involve any additional strain.

Experiments on the Rate of Propagation of an Electric Current.—Upon the telegraph line between Bâle and Lucerne M. Hagerbach has recently carried out some experiments to determine the rate of propagation of the current. His method is extremely beautiful and ingenious, and is based upon the well-known experiment of Lissajous, in which a ray of light is reflected successively from the prongs of two tuning forks which vibrate in planes at right angles. If the forks are precisely in tune, then the resultant motion of the reflected ray describes upon the screen either a right line, an ellipse, or a circle according to the relative *phase* of the vibrations of the two forks. In M. Hagerbach's experiment the vibration of the forks is maintained by an electro-magnet make-and-break in the usual manner. The electro-magnets are placed in circuit with a battery, and a switch is arranged so that the telegraph line can be thrown into circuit between the two magnet coils. The line being first cut out of circuit it is found that the spot of light describes a narrow ellipse, showing that the phase of the second tuning fork is slightly behind that of the first owing to the retardation in the coils of the magnet. But as soon as the whole length of the line is thrown into circuit the ellipse widens out, and thus visibly demonstrates the increase of retardation. From measurements of the figures described the time of retardation can be calculated. M. Hagerbach made the experiments over various lengths of line, but the actual values obtained are not of much value owing to the very complex nature of the problem. The retardation varies directly with the square of the resistance, but it depends also upon the permittance, inductance, and impedance of the circuit, and of these terms no record is given. The results showed, however, considerable departure from the simple ratios of the squares of the resistance of different lengths of the line. A full account of the experiments will be found in *Wiedemann's Annalen*, Vol. XXIX., p. 377.

A Remarkable Improvement in Link Leather Belting. Several of the electric lighting stations in Boston are now employing a link leather belting made by Mr. C. L. Ireson of that city which is said to yield results of a remarkable character. The improvement consists in making the belt in two or more longitudinal sections, which are hinged together by their edges; the hinges are about the same length as the other links, but the joints of these links run the opposite way—that is, parallel to the length of the belt. By this means a flanged pulley is unnecessary, and the belt fits itself over a round or cone-faced pulley almost in the same way as a plain belt. For the smaller sizes only two sections—that is, one longitudinal hinge—are used; but as the width of the belt is increased the number of sections is also augmented. In this way, moreover, full advantage may be taken of the great weight of link leather belting, and it becomes possible to run with a very slack belt. At the recent meeting of the American Electric Light Association at Boston a 3in. belt of this description was employed to transmit power from a 6 horse-power electric motor to a countershaft, from which two 4in. plain belts drove some other machines. In this case (we quote the New York *Electrical World*) "the link belt was so slack on the following side that in running from a 5in. pulley to a 24in. pulley, which were set about eight feet apart on the centres, there was a sag of about ten inches from the straight line which would have joined the highest points in the crown surface of the pulleys, the sag of the belt bringing the lower part of it within four inches of the hauling side of the belt. In consequence of this sag the lap of the belt on the small pulley was more than a semi-circumference, while with ordinary belting this lap would have been somewhere from a quarter to a third of the circumference. As a result of this there was no slip, and a much narrower belt could be used than if frictional contact between the belt and the pulley had been required to be made by the width of the belt instead of by the length of the same."

Electric Lighting Accidents in America.—An American journal reports that Frederick Nelson, aged 21 years, a lineman employed by the Brush Company of Philadelphia, was recently killed whilst connecting wires running into No. 511, South-street, Philadelphia, with the main current. Mr. D. Law, general superintendent of the company, who examined the wires immediately after the accident, said the main wire had apparently been cut, and the young man had evidently been attempting to splice the "cut-out" so as to continue the current. The "cut-out," the superintendent continued, is a piece of wire several feet long, the ends of which are spliced to the main wire when a connection is to be made. It acts as a safeguard when the main wire is cut between its ends, the current being at once diverted into the "cut-out." There is a systematic way of proceeding about making connections, and the linemen are called together monthly and expressly cautioned not to follow any other method. The "cut-out" is first put in place, and then the main wire may be cut with comparatively little danger. In this case, however, he said, it seems as if the main wire had first been cut, and an attempt to splice the "cut-out" made afterwards. Nelson had been employed by the company since April, and was regarded as a capable workman.—An accident of a peculiarly distressing character is also reported to have occurred to a young girl who was being taken over a central lighting station. It appears that the end of a loose wire connected with a machine of high potential became entangled with her dress, and in some way made metallic connection with her body in the neighbourhood of the spine. She received a severe shock, and for upwards of four days the poor girl remained completely paralysed, notwithstanding the care with which the doctors attended to her case. Then she recovered the use of her limbs; but at the same time, though there was no perceptible loss of appetite, she began to lose flesh, and continued wasting away until she is now described as a mere skeleton. Her hair, moreover, which had turned completely white, has fallen off, and her skin is wrinkled and withered like that of an aged woman.

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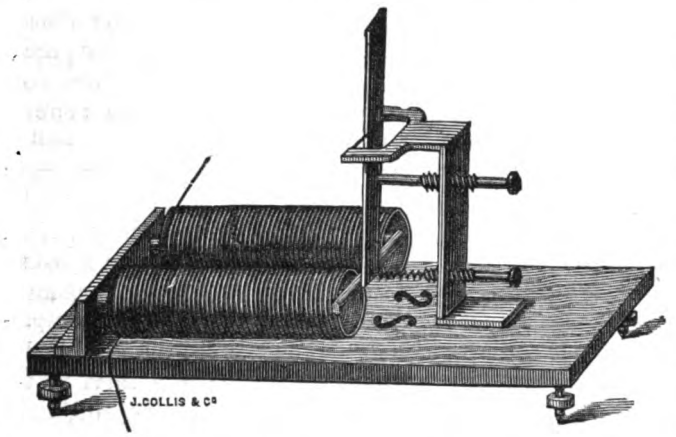
THE RISE AND PROGRESS OF TELEPHONY IN THE UNITED KINGDOM.

(Continued from page 475.)

We reproduce from our last chapter the engraving of the most interesting and important of the Reis receivers. Our knowledge of this instrument is solely derived from a paper "On the Reproduction of Tones by Means of Electro-Galvanism,"



by V. Legat, Inspector of the Royal Prussian Telegraphs in Cassel. This paper appeared in 1862, in the *Journal* of the Austro-German Telegraph Society (Vol. IX., p. 125); a full translation is given in Prof. Thompson's book, and from this we take the following description of the apparatus:—

"The receiver consists of an electro-magnet, which reposes upon a sounding box, and whose wire coils are respectively connected with the metallic conductor, and with the earth or metallic return conductor.

"Opposite the electro-magnet stands an armature, which is connected with a lever, which is as long as possible, but light and broad.

"The lever is fastened, pendulum-wise, to a support, and its movements are regulated by a screw and a spring.

"In order to improve the action of the apparatus, this receiver can be placed in one focus of an elliptically arched cavity of corresponding size, in which case, then, the ear of him who is listening to the reproduced tones may be placed at the second focus of this cavity.

"The action of the two apparatuses here described is the following:—

"In a condition of rest the galvanic circuit is closed.

"In the transmitting apparatus, by speaking (singing, or leading into it the tones of an instrument) into the tube, in consequence of the condensation and rarefaction of the air present in this tube, there will be evoked a motion of the membrane closing the tube at its narrow end, corresponding to this condensation or rarefaction. The lever follows the motion of the membrane, and opens and closes the galvanic circuit, so that by each condensation of the air in the tube an opening, and at each rarefaction a closing of the galvanic circuit ensues.

"In consequence of this process the electro-magnet of the receiver will be demagnetised and magnetised correspondingly with the condensations and rarefactions of the mass of air in the tube [the mouthpiece of the transmitter], and the armature belonging to the magnet will be set into vibrations similar to those of the membrane in the transmitting apparatus. The plank, connected with the armature, conveys these similar vibrations to the air surrounding the apparatus, which finally transmits to the ear of the listener the tones thus produced.

"We are not, therefore, dealing here with a propagation of sound through the electric current, but only with a transference to another place of the tones that have been produced, by a like cause being brought into play at this second place, and a like effect produced.

"Here, however, it must not be overlooked that the preceding apparatus reproduces, indeed, the original vibrations in equal number, but that equal strength in the reproduced vibrations has not yet been attained, and the production of these is reserved for a completion of the apparatus.

"One consequence of this temporary incompleteness of the apparatus is that the slighter differences of the original vibrations are more difficult to discern; that is to say, the vowel appears more or less indistinct, the more so since each tone is dependent, not only on the number of vibrations of the medium, but also on the condensation or rarefaction of the same.

"By this it is also explained that, in the practical investigations heretofore carried on, chords, melodies, &c., were transmitted with marvellous fidelity; while single words uttered as in reading, speaking, and the like, were perceptible more indistinctly. Nevertheless, here also the inflexions of the voice, the modulations of interrogation, exclamation, wonder, command, &c., attained distinct expression.

"There remains no doubt that before expecting a practical utilisation with serviceable results (praktische Verwerthung mit Nutzen), that which has been here spoken of will require still considerable improvement, and in particular mechanical science must complete the apparatus to be used; yet I am convinced by repeated practical experiments that the prosecution of the subject here explained is of the highest theoretical interest, and that our intelligent century will not miss the practical utilisation (Verwerthung) of it."

It will be interesting at this point to mention that in his "Rede Lecture" for 1878, Prof. J. Clerk Maxwell referred to the Reis telephone in the following terms:—

"If the pitch of a sound were the only quality which we are able to distinguish, the problem of telephony would have received its complete solution in the instrument of Reis. But the human ear is so constructed, and we ourselves are so trained by continual practice, that we recognise distinctions in sound of a far more subtle character than that of pitch, and these finer distinctions have become so much more important for the purposes of human intercourse than the musical distinction of pitch that many persons can detect the slightest variation in the pronunciation of a word who are comparatively indifferent to the variations of a melody."

Clerk Maxwell evidently shared the impression of Reis himself, that no effect could be obtained unless the platinum contacts underwent complete separation—in other words, that the transmission must be by make-and-break. This was in 1878. We are now better prepared to understand, or at any rate to accept, the fact that provided the adjustment was such that a sound of given volume only stirred without completely breaking the contact, the characteristic harmonies might be faithfully reproduced, and speech thus become possible. This is what the Reis transmitter can do, provided always that it be spoken to in a sufficiently gentle tone. On this point Prof. Sylvanus Thompson in his evidence at the trial in question spoke as follows:—"Reis's transmitter was intended by the inventor to work as a make-and-break contact instrument; and the inventor expected it to produce articulate speech by this action. As a matter of fact Reis did obtain articulate sounds, *but this was when the instrument worked in a manner which it was not intended it should.*" Even when spoken to in a gentle voice the transmission is usually very imperfect, continual interruption occurring as a "break" takes place.

Not much, however, was made of the transmitter on either side. Edison had already disclaimed one of his instruments in which a pair of platinum contacts were employed, although there was this important difference—the two contacts were permanently connected through a high-resistance shunt. Although the Reis telephone was mentioned amongst the particulars of objection to the Edison patent, and was referred to in evidence, the point was not pressed by the defendant's counsel, and was not alluded to by the learned judge in his decision. The fact seems to be that notwithstanding, on the one hand, it has been denied that the Reis transmitter will transmit articulate speech at all, it has not, so far as we are aware, ever been asserted, on the other hand, that the instrument is capable of fulfilling the conditions of practical telephony.

(To be continued.)

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ELECTRIC MOTORS FOR THE SPANISH NAVY.

Messrs. Immisch and Co. have just completed a very interesting electrical plant for the Spanish Navy. The plant includes two 30 horse-power, three 4 horse-power, and one ½ horse-power motors. The machines were all built to the specification of the Spanish Naval Commissioners, and were tested in the presence of three of their representatives. The tests showed that the contractors had fully discharged the conditions of the specification. The annexed tables give the figures obtained from one of the 30 horse-power motors. The horse-power given out was measured by a Prony brake. The diameter of the pulley was 24in., and the face 17in.; the length of the arm of the brake was 63in. The brake was balanced so that it was only necessary to read the actual weight on the arm. The formula used was

$$\text{Horse-power} = \frac{2\pi l n w}{33000},$$

where l = length of brake arm in feet, n = revs. per minute, w = weight on arm in lbs. Putting $l = 63$in., we have

$$\text{Horse-power} = \cdot 001\, n\, w$$

which is a very convenient form for calculation.

Speed.	Weight in lbs.	Volts.	Amps.	H.-P.	E.-H.-P.	Efficiency.
660	45¼	500	49	29·8	33	90
680	45¼	500	48	29·5	32·2	91
675	45¼	500	49	29·5	33	89

[The figures given are those observed and recorded by the Spanish Naval Commissioners.]

The resistance of the armature was ·47 ohm, and that of the field ·355. These resistances were taken when the machine had acquired the normal temperature for full output. The volts lost over the resistance of the machine were $49 \times \cdot 825 = 40 \cdot 5$ volts. Therefore the theoretical possible efficiency of conversion was $\frac{459 \cdot 5}{500} = 92$ per cent. nearly. The actual efficiency obtained averaged 90 per cent., allowing about 2 per cent. loss for mechanical friction, Foucault currents, &c.

The 30 horse-power motors weigh 17cwt. Each machine is fitted with a resistance frame, divided into three sections for starting. The reducing and make-and-break switches are so arranged that all the resistance must be put into the circuit before *breaking*; hence it is impossible to start without first running through the resistance. A large supplementary switch, with an extra long break, is also provided for use in conjunction with the reducing switch, or separately, in case of emergency. It is intended to run the motors from accumulators, and provision has been made to couple the cells in single series or two parallels, thus giving full or half speed on the motor shaft. The commutating switch used for this purpose is locked by the reducing switch in such a manner that it is only possible to change the coupling of the cells after the circuit is broken on the reducing switch. This obviates the risk of short-circuiting the accumulators. The direction of motion is changed by reversing the current in the armature. A sufficiently substantial switch is provided for this purpose. The brushes are of the Immisch, balanced, tangent type. The machines run very smoothly, and are practically sparkless.

LITERATURE.

Electricity for Public Schools and Colleges. By W. LARDEN, M.A. (London: Longmans, Green and Co. 1887.)

"In this course the writer aims," says the preface, "at giving a sound though elementary knowledge of electricity." Upon the whole, we have come to the conclusion that—so far as the purpose can be accomplished by mere book work—there is no treatise at present in the field better adapted to fulfil the intention of the author than this of Mr. Larden. We shall have something presently to say in criticism of the author's general method, but first let us give an intelligible reason for the somewhat sweeping verdict which we have pronounced. It is impossible to go through these pages without being struck with the firm grasp which the author at every point displays, not merely of the subject in hand at the moment, but also of the exact amount of information which he has hitherto imparted, and the precise degree of knowledge—so much and no more—which the pupil is at each stage supposed to have attained. Now, this is one of the points upon which so many otherwise excellent text books are sadly at fault. It is undeniable that one of the most serious difficulties which is encountered by elementary students of physical science arises from the fact that there does not and cannot possibly exist any natural and inevitable order of discourse upon the phenomena of the universe. In Nature there is neither before nor after, all things co-exist. It is but a truism to say that the complete elucidation of a single one of the so-called "elementary" phenomena would in general require such a knowledge of molecular physics as is yet utterly—perhaps hopelessly—beyond our reach. Our method of separating and labelling phenomena as "electrical," "chemical," "thermal," "optical," &c., is highly convenient, no doubt; but, after all, it is only a rough-and-ready means of getting over a preliminary difficulty, and of penetrating the realms of the unknown from various different directions. A valid conception of the principles of no one science can be obtained without more or less acquaintance with the progress which has been made along many convergent paths.

The task of the teacher of science is therefore to select what to his judgment appears—in the then stage of scientific progress—the best, and safest, and easiest course along which to conduct his pupil. The selection must of necessity be arbitrary; and cannot therefore possibly be proof against criticism at every point. But when once the choice is made what is of vital importance is that the writer should clearly realise in his own mind the ins and outs of the devious paths along which he undertakes to guide the student. In this essential qualification Mr. Larden appears to us to attain an unusual standard of excellence. The sciences with which electricity is most closely in touch are those of Chemistry, Mechanics, and Heat. The author demands at the outset an acquaintance with as much chemical knowledge as may be gleaned from the elementary text books of Roscoe and others of similar grade. In Mechanics he had intended, he says, to include such propositions as are necessary where and when they are first required. Considerations of space, however, forbade this plan, and for the most part he has been content "to indicate merely the exact amount of knowledge required." The latter remark would in general also apply to his treatment of the theory of heat.

An equal care to discriminate the supposed condition of mind in the student is manifested in the treatment of the various divisions and sub-divisions of the main subject. Cross references to various parts of the work continually occur, and when the exigencies of the treatment adopted require them such references are carried forward as well as backward.

As to the substance of the lessons, our space will not permit us to enter into detailed criticism, because we have yet to pick a quarrel with the author upon a question of more general interest. We must therefore be content to observe that the work is brought well up to date, is in general both lucid and accurate, and contains just about as much mathematics as is indispensable to a proper understanding of the theory without burdening the pages with unnecessary symbols. The calculus is not introduced. There is a salutary and refreshing absence of many (though not quite all) of the hackneyed diagrams and illustrations which have done duty in most text books for the last twenty years, and a corresponding introduction of numerous figures, some of which we now meet with for the first time in a volume of this character—though as regards the instruments shown, most, if not all, have at various times appeared in our own columns. Mr. Larden's book should, in brief, be accorded a place in the literature of the more purely theoretical treatment of electricity beside that of Ayrton's "Practical Electricity," or of Stewart and Gee's

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recent work on the more experimental side; and would serve as an introduction to Cunnyngham's "Theory of Electricity."

Having said all this we have now to express an opinion that Mr. Larden's whole course of treatment is fundamentally wrong. It is the very excellence of the book which makes us think it worth our while to express this emphatic opinion. But let us explain. We have said that every systematic course in physical science must necessarily rest upon an arbitrary decision as to the order of treatment, and it can be little more than a matter of opinion as to which of all the possible schemes is the best. Our opinion is that the scheme selected by Mr. Larden is not, on the whole, the best possible, though in many of the details it is doubtless a good deal better than certain others which might be named. It would, perhaps, be not impossible to defend the thesis that of all possible orders the historical is the worst. Without going as far as this, we cannot fail to recognise that the writers of text books have in general allowed themselves to be far too much under the domination of the historical order of discovery. Mr. Larden, as we cordially recognise, has to a considerable extent emancipated himself from this groove, and indeed in the preface he expressly disclaims any idea of conveying a notion at the same time of the principles of the science and of its chronology; but having gone so far we have only to regret that he did not go further. Let us—in part to economise space, and in part to offer a constructive rather than a merely destructive criticism—content ourselves with the bald statement of Mr. Larden's order of treatment, and then briefly set forth what we conceive to be a more consecutive and more generally appropriate scheme. Our author's main divisions are in order as follows:—Elementary Magnetism, the Simpler Phenomena of Electro-Statics, Introductory Chapter on Potential, Condensers, Induction Machines, Atmospheric Electricity, Electric Currents and their Phenomena, Ohm's and Joule's Laws, Thermo-Electricity, Magnetic Actions of Currents, Magnetic Fields, Solenoids and Electro-Magnets, Electro-Magnetic Induction, Rhumkorff's Coil, Dynamos, and other practical applications. We have omitted to put down several of the minor divisions. A consideration of this scheme will necessarily reveal that there are numerous cases of *non sequitur*—"faults" in the geological sense. Now we take it that it must be a criterion of the relative excellence of rival schemes that the one which is able to cover the most ground in consecutive order is, other things being equal, the better.

The following would be our own scheme; but in making the comparison we do not fail to recollect that Mr. Larden has written his book with all its detail, while we are only laying down the first broad outlines of an ideal. The reader will not fail to bear this in mind, although we shall still expect him to decide that of the two schemes our own is decidedly the more promising.

We take it that both in magnetism and electricity, as well as in electro-statics and electro-dynamics, the fundamental conception with which the pupil has to become familiar is that of the circuit. Now, there can be no two questions that the most simple, visible, and tangible circuit is discovered in the properties of the voltaic cell. Here, then, we should begin. It is tempting, no doubt, to rub a glass rod and show the student the strange and almost startling powers it has acquired. It is calculated, no doubt, to enlist his attention to promise some further elucidation of the mysteries of the familiar compass needle, and of the red-painted horseshoe magnet. But if we assume—as Mr. Larden most properly does—an elementary acquaintance with chemistry, then surely it is more useful to take a piece of copper and of zinc in dilute acid, and to discourse at once of the nature and properties of the voltaic current. We must not now stay to work out details, but it is obvious that the action of solenoids would lead directly to the discussion of electro-magnetism, where two paths would diverge, the one to the phenomena of the permanent magnet, and the other to that of dynamic induction. The conception of the magnetic circuit could probably be introduced quite early with advantage. Electro-statics, admittedly the most difficult branch of any, might, perhaps—we speak here with some additional diffidence—be approached with advantage through the phenomena of the Rhumkorff coil. But, however this may be, we feel on sure ground when we insist upon the necessity of introducing at an early stage of this branch of the subject the conception of the electro-static circuit. This is but a bare skeleton of a scheme, yet we venture to think it capable of not unsatisfactory development.

But even though Mr. Larden has not written upon our plan, his work is still among the best of its kind with which we are at present acquainted.

On a Surf-Bound Coast; or, Cable-Laying in the African Tropics. By ARCHER P. CROUCH, B.A. (London: Sampson Low.)

Our first feeling on opening a book of this description is one of surprise that hardly anything of the kind has been ever attempted before. The opportunities afforded by cable-laying expeditions, and the leisure at the command of those who have to work the cables when they are laid, are so pregnant with foreign travels and adventures, that one would have thought the telegraph profession might have found a market for its experiences long before now. Mr. Crouch has begun well, and we hope that his example may be imitated by other hands. We may hope, too, that they will take warning by some of the blemishes which disfigure what in the main is a very readable and entertaining book. The diary style is about the worst that could be adopted for a continuous narrative; the disguise of all the names, both of ships and men, detracts from the veracity of the story, and is, so far as we can judge, a quite unnecessary piece of reticence. Lastly, the author commenced his diary apparently with no fixed object, and to the very end of it does not seem clear as to whether he intends it as a book of travel or a record of chit-chat. To Mr. Crouch himself, and to others of his profession who may aspire to follow in his footsteps, the best advice we can give is, before putting his notes into book form, to ask himself the question, For whom am I writing? Lovers of books relating to travels in strange lands are extremely numerous, and works of that description are the more saleable for being written in a lively vein with occasional strokes of jocularity. Mr. Crouch unfortunately tells us far too little about the towns and peoples on the West Coast of Africa, but far too much of the doings and conversations of the people on board his ship. Only three months of the voyage are included in this volume. With judicious pruning in one direction and grafting in another it might have covered the whole six months, and been very much improved by the process. Mr. Crouch is a keen observer of men and things, and he possesses both the powers of description and the gift of narration so needful for a work of this kind. His account of the landing in a surf boat (p. 235) is an admirable sample of the former, only there is too little of it; whilst of the latter the examples are far too numerous, many of the incidents and dialogues having no interest whatever except for the parties engaged in them. Apart from these faults, however, "On a Surf-Bound Coast" is a capital book of its kind, and the reader will find on almost every page something to attract and amuse him.

AN IMPROVED EARTH PLATE.—Prof. Dorn, in the *Electrotech. Zeits.* for October, proposes a form of earth plate which should be valuable to all observers of earth currents, if, as is claimed for it, it reduces polarisation to a minimum. It consists of a flat open box, made of wood or cement, and coated inside with asphalte. This is placed at the bottom of a hole in the ground. An amalgamated zinc plate lies flat in the box, and an insulated wire leads from it to the surface. Care must, of course, be taken that the joint is well covered, so that nothing but zinc is in contact with soil. An earthenware pipe stands on the zinc and rises to the surface. The box is then tightly rammed with clay, soaked with concentrated zinc sulphate solution, and the hole filled up. Solid sulphate is dropped down the tube and solution poured after it. A little fresh sulphate from time to time will keep the plate in order.

SOUTH OF ENGLAND TELEPHONE COMPANY.—The Directors of this company have declared a dividend of 6 per cent. per annum on the Preference Shares for the half-year ended 31st October.

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THE ELECTRICIAN.

TO CORRESPONDENTS, SUBSCRIBERS, AND ADVERTISERS.

All Communications to be addressed to THE ELECTRICIAN, *1, Salisbury-court, Fleet-street, London, E.C. Cheques and Money Orders should be made payable to* THE PROPRIETORS.

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THE ELECTRICIAN *can be had, by order, from any newsagent, in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—*

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	s. d.	s. d.	s. d.
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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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INDEX TO VOLUME XIX.

With this number a Supplement is issued (Gratis), containing the Index to Volume XIX. This Supplement should be received with every copy of the paper. Complaints of non-receipt should be at once forwarded to the Publisher.

NOTICE.

We beg to notify that all correspondence and contributions intended for this Journal should be in future addressed to THE ELECTRICIAN, 1, Salisbury-court, Fleet-street, E.C., instead of to Mr. C. H. W. Biggs, whose connection with it has ceased. We deem it right to add that no other change whatever has occurred or is contemplated in the proprietorship or management of this Journal.

SCIENCE AND BUSINESS.

It was far from our intention to raise any dispute about the functions of Science and Trade when we took up the scheme of an Electrical Engineering Association. But some people are hard to please. In deference to the scientific branch of the profession we disclaimed all idea of invading its province, and this with an emphasis which was intended to be reassuring, but which has been interpreted as abandoning the proper functions of scientific and technical journalism in order to "take the commercial affairs of our readers under protection." This is an attitude which fills our contemporary, *Engineering*, with amazement, and serves as a text for a good deal of tall talk about science and a vast amount of disparagement about business. For our part we have no hesitation in confessing that the protection of "our readers" is regarded in this office as one of the duties we owe to those readers, whether their interests be scientific or commercial. That this view of their duty is shared by the majority of our electrical and engineering contemporaries is confessed by the journal which so loftily takes them to task. The highly moral isolation in which *Engineering* has entrenched itself does not very much concern us; but we take leave to remark that it does concern the "readers" of that technical and scientific organ, and that it will find the reckoning with them not so simple a matter as writing a derisive article about them.

Except to remove any remaining misapprehensions with regard to the proposed Association of Electrical Engineers, we should not have referred to the line taken up by our esteemed contemporary, whose freedom of criticism and action we do not in the least dispute. But we must demur to the designation TRADES UNION as applied to this scheme, and still more to the suggestion that it is intended to dissever itself altogether from "the principles of science or the practical application of them." The latter is impossible; we have distinctly said so more than once, and the phrase "except indirectly" in the passage quoted from our leader in support of the opposite contention indicates that we have never lost sight of the fact that any association of the kind under discussion must be directed on scientific principles, and must receive its inspiration primarily from scientific teaching. Indeed, it is the absence of this steadying element in the profession of electrical engineering, including, as it now does, the tinker and tailor, if not the soldier and sailor, that operates to its discredit and tends to bring it to ruin. Existing professional and trade associations have been formed, partly, at least, to exclude incompetent intruders who have no business to be there—an object surely in complete harmony with those superlatively scientific and technical aims which our contemporary has propounded. It is admitted that the programme we have sketched out is "desirable and laudable;" but the affairs embraced in it, says *Engineering*, "do not come within our province ..... and nothing is further from our intention than to put ourselves in the false position of supplying an initiative to a body of men who are perfectly capable of acting for themselves."

In justification of this remarkable deliverance our contemporary disclaims "all pretensions to deal with the commercial aspects of engineering." It is our turn now to be amazed. We cast our eyes over the pages which contain this notable utterance to see whether they differ from the pages familiar to us in times past. They literally bristle with "commercial aspects," and, to repeat our own words, "except indirectly, they have nothing whatever to do" with science. And then, how about the advertisements? But we will not pursue the examination. It is really too painful; and we may dismiss it with the remark that if the readers of a journal can be judged by the matter given them to read, then the journal referred to is as much beholden to, as much dependent upon, and as much devoted to the commercial affairs of its readers as every one of its contemporaries. The chief difference appears to be that in respect to the scheme promoted with more or less warmth by its comrades, *Engineering* has chosen to adopt a tone of superiority which not only quarrels with the bread and the butter, but sneers at the bakers and dairymen. For besides accusing them of trying to form a trade ring, Electrical Engineers are described as being selfish and thoroughly distrustful of each other; and with very good reason apparently, as they are generally engaged in the "process of mutual throat cutting." If this were a faithful description of the electrical engineering profession it would

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be pretty clear that it is not composed of men quite competent to take care of themselves. But in that case the services of their recognised organs in the Press are all the more needed; and we have no right to stand aside, letting the trade or profession, or whatever we please to call it, go to the dogs under the pretence of having no concern with it. Whatever comes of the proposed Association we declare our conviction that we are serving the interests both of science and of its practical application by assisting those engaged in promoting the latter; and if they are convinced, as indeed they appear to be, that the present unsatisfactory condition of the trade might be set in order by associated action, we shall do what we can to help them.

It is useless, however, to deny that in the article on which we have been commenting there are indications of a genuine alarm for the safety of existing institutions, such as that of the Civil Engineers and the Society of Telegraph-Engineers. We are warned that the last named society "will be quite equal to meeting the occasion if the new Association should develop a scientific aspect;" and no doubt our friends will take note of the warning, which, though oddly worded, is seriously meant. We do not share these apprehensions; we rather think the electrical engineers could meet very profitably without developing any aspect hurtful to the feelings of that or any other society. But if we did feel any misgivings on this point we should at once say to the society threatened that it had better be quick in "meeting the occasion." We strongly deprecate the formation of any society that would run counter to the welfare of established institutions. What we say, and what our friends feel, is that no existing organisation provides at all for the wants which electrical engineering, considered as a business profession, has developed. That, we venture to assert, must be admitted; and, once admitted, we see no reason why those wants should remain unsatisfied because other societies of a kindred order cannot satisfy them. If they think they can, and will try, why, let them set about it at once. Meanwhile steps are being taken to ascertain what is the feeling of our correspondents on this as well as on other points connected with the idea of a new association.

THE COWLES ELECTRIC FURNACE AND THE ALUMINIUM ALLOYS.

The gigantic dynamo machine built for the Cowles Electric Smelting and Aluminium Company by Messrs. R. E. Crompton and Co. is this week being erected at the company's works at Stoke-on-Trent. This machine is considerably larger than the Brush "Colossus," which has been at work since September, 1886, at Lockport (U.S.). The Brush machine absorbes 350 horse-power, while the Crompton machine has a guaranteed minimum capacity of 300,000 watts (5,000 amperes and 60 volts), and will require 500 horse-power. We shall hope shortly to place before our readers full details of this machine, and of the Cowles process as carried out at Stoke-on-Trent; meanwhile, the following extract from the report of the Committee of the Franklin Institute which was appointed to examine the works at Lockport, U.S., will be of interest:—

The essential and valuable novelty of the process is the ingenious application of the intense heat, obtained by the passage of a powerful current of electricity through a conductor of great resistance, to the reduction in the presence of carbon of the most refractory ores, some of which have hitherto resisted all similar attempts at reduction. In this process, the crushed ores are mixed with fine charcoal, and, for the production of alloys, with fragments of copper, or some other metal or metals from the part of the circuit offering the greatest resistance to the electric current, and subjected therefore to the highest temperature. The heat developed is so great that nearly all oxides are decomposed, and charcoal is changed to graphite. . . The process is applicable to all kinds of ores, but particularly to those unreducible by other means.

The value of aluminium bronzes and other alloys containing aluminium is so well known that we shall only say a few words concerning them. Full and interesting details may be found in metallurgical works, chemical dictionaries, engineering, and special text-books. All authorities unite in their phrase, and predict an extensive use for them. Their high price alone has prevented their general employment in the past, but in spite of their costliness the demand is not inconsiderable. The usefulness of the aluminium bronzes is due to their great hardness, tensile strength, and stiffness.

They are also ductile, malleable at high temperature, and elastic. They resist the action of the air, moisture, and many other chemical agents, far better than brass or bronze. The lustre of silver or gold may be given to them. Under some conditions silver and gold tarnish much more readily than the aluminium bronzes. They may be cast, rolled, or forged. The castings are of great strength and homogeneous; repeated meltings only slightly decrease their tensile strength, without causing any loss of weight. Large castings may be made with care; small castings are readily secured.

The Lockport Works will have a capacity of six thousand pounds daily, and the company expects to profitably sell the 10 per cent. aluminium bronze for less than forty cents per pound—in fact, Mr. Cowles intimates in the paper that the price may be as low as fifteen cents per pound.

The Cowles Electric Smelting and Aluminium Company promises to furnish within a year pure aluminium for fifty or sixty cents per pound. If raw material of sufficient purity can be obtained cheaply, this can probably be done. . . The members of the committee have, moreover, no doubt of the ultimate success in the production of pure aluminium at a moderate cost.

The scientific possibilities of the invention must not be overlooked. The intense heat of the electric current is so completely under the control of the operator, and the other conditions are so favourable, that not the slightest doubt should exist of speedy and valuable additions to our knowledge of metallurgical and chemical processes. Already aluminium alloys of iron, silver, tin, cobalt, and nickel have been prepared. Silicon bronze, potassium, sodium, magnesium, calcium, chronium, and titanium, as well as aluminium, have been obtained in a free state. An apparently new oxide of silicon awaits supply. The opportunities for the formation of new and important alloys seem unlimited, and it is not improbable that some of our *elements* may be resolved into different kinds of matter.

Much speculation is, however, out of place in a report of this kind, but the committee is of opinion that the Messrs. Cowles and their associates deserve the highest commendation for their inventions, furnishing as they do a distinctly new and important metallurgical process that will render possible the cheap production of useful alloys, compounds, and metals, and giving to science a valuable aid in research.

THE RIES ELECTRIC TRACTION-INCREASING APPARATUS FOR RAILWAYS.

Mr. Ries' apparatus and method of increasing tractive power on rail or tramways will be found fully described on page 391 of the present volume. It appears to us that this system is likely, perhaps in the near future, to obtain a position of recognised importance amongst the applications of electricity. At the Exhibition of the American Institute of Electric Engineers a working model of the system is now being shown. We take the following from the New York *Electrical World*:—

One of the most recent as well as one of the most valuable and interesting of the electrical exhibits is that of Messrs. Ries and Henderson. This exhibit is at present in charge of Mr. Ries himself, and attracts a great deal of attention, even from non-scientific visitors, who view with mingled wonder and delight the novel spectacle of a model railway car ascending, without the slightest difficulty, a grade upon which an expert tobogganist might fear to entrust himself for a downward trip. The outfit comprises two model railway tracks, each capable of being elevated at one end to various heights, with a motor-car for each track, and a dial for registering the amount of pull or tractive force exerted by the cars under different conditions. The Ries electric traction-increasing system embodies a new application of electricity, one that gives promise of a wide and extensive field of usefulness, especially in connection with steam and electric railways, and is particularly valuable at the present time in view of the possible influence it may bring to bear upon the successful development and introduction of electric street railways. It is well known that one of the greatest obstacles that have been encountered in applying motors, whether steam, compressed air, electrical or any other kind, to the operation of street railways has been the difficulty of securing sufficient adhesion between the driving wheels and track in wet or slippery weather, and especially so on railways having steep grades. In this respect cable and horse cars have heretofore had an advantage because of the application of the tractive force independent of the car itself, and, therefore, independent of the amount of friction or adhesion between the wheels and track rails. As the ordinary street car rails are necessarily level with the street surface, they do not permit of the same tractive effect as the elevated rails commonly used on steam and suburban railways, and it has therefore been possible to employ independent motors successfully only on roads having grades of less than 6 per cent., or a rise of 6ft. in a length of 100. In view of the fact that many street railway lines have grades of from 10 to 15 per cent., it does seem self-evident that some method of artificially increasing the frictional adhesion of the

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driving wheels must be employed before electricity can be successfully utilised as a motive power for operating street cars in our crowded cities on steep grades. In one of the model cars exhibited by Messrs. Ries and Henderson this increased adhesion is produced in a very simple and inexpensive manner by means of magnetising helices or coils of wire on each axle, through which a current of electricity is passed whenever this additional tractive force is desired, as, for example, when starting a heavy load, or on going up an incline, or in case of a slippery track. So effective is this method that the car shown readily ascends a grade of 40 per cent., or 2,083ft. to the mile, by virtue of the magnetism induced in the wheels, and the peculiar arrangement of the magnetic circuit. The rolling motion of the wheels is not appreciably affected, and the amount of current required for producing this magnetising effect is extremely small and insignificant when compared with the results obtained. The second model above referred to represents the operation as applied to steam railways. Instead of magnetism, a different arrangement is employed in which the molecular action of an electric current of large volume is caused to increase the frictional adhesion between the locomotive driving wheels and the track. This property of the electric current was observed and its commercial importance pointed out by Mr. Ries, in a paper read by him before the American Association for the Advancement of Science, at the recent meeting in this city. In this system the locomotive is preferably provided with a small alternating machine, the current from which passes through a "converter" to give it the required volume, and this current is then led to the forward pair of driving wheels, which are insulated from the body of the locomotive. From these wheels the current enters the track and flows back to its source by way of the rear pair of driving wheels, the arrangement being such that only that portion of rails which lies between the two pairs of wheels is in the electric circuit. Consequently no danger from shock by coming in contact with the rails exists. The tractive effect is due to the molecular change and heat produced by the current at the point of contact between the wheels and rails, which causes a very decided increase in the coefficient of friction between the two surfaces, and prevents slipping or skidding of the wheels. The amount of current passing can be regulated by the engineer to suit different conditions of track and load, and it is claimed that an increase of from 50 to 100 per cent. in the tractive power of existing locomotives can be obtained with a very economical expenditure of current.

BARDONNAUT'S "SOURDINES."

The adjoining figures illustrate several forms of the "sourdine ressort" (or spring muffler), introduced by M. Bardonnaut, for checking the noise caused by the vibration of telegraph wires. This is the arrangement referred to by Mr. Charles Bright in his letter on page 520. No further explanation will be required. These devices, though obviously of only limited application, may at

FIG. 1

FIG. 2.

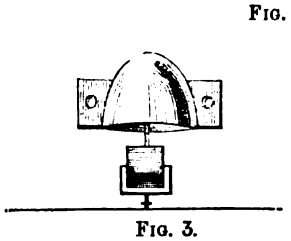


FIG. 3.

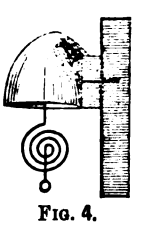
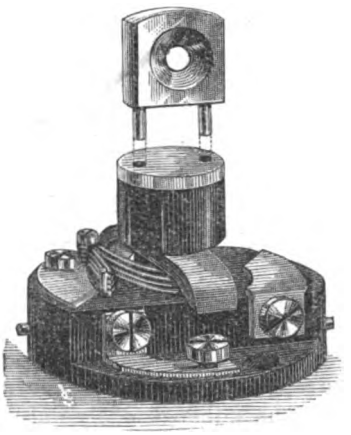


FIG. 4.

times prove useful. We believe that some use has been made of them by the United Telephone Company, though at one time they preferred to insert a short piece of chain in the line where the sound caused annoyance. The arrangement shown in Fig. 2, which is most like that proposed by Mr. Caws, differs, however, from the latter in the fact that it requires a joint on each side of the insulator. Figs. 3 and 4 are front and side views respectively of a bracket arrangement.

NEW WOODHOUSE AND RAWSON SWITCH.

The adjoining figure represents a switch of useful pattern which has recently been introduced by the Woodhouse and Rawson Manufacturing Company. The switch is represented in the figure with the case removed. The base is of slate, and a powerful throw-off spring with good rubbing contacts are provided. The thumb-



screw is made detachable, so that the switch cannot easily be tampered with by any unauthorised person.

ON THE THEORY OF ELECTRIC ENDOSMOSE AND ALLIED PHENOMENA, AND ON THE EXISTENCE OF A COEFFICIENT IN CONTACT WITH A SOLID.*

BY PROF. LAMB, F.R.S.

The paper deals with the laws governing the electric transport of ions in conducting liquids through the cells of porous vessels or along capillary tubes and other related phenomena which have been investigated experimentally by Profs. Wiedemann and Quincke, and explained by the latter writer on the assumption of the contact difference of potential between the fluid and its solid boundaries. This explanation has been developed mathematically by Von Helmholtz. Applying the known laws of motion to viscous fluids he found that the calculated results so far as they depend on quantities which admit a measurement are in satisfactory agreement with the experiments, and that the values which it is necessary to assign to the contact difference above spoken of are in all cases comparable with the E.M.F. of a Daniell cell. Incidentally, also, he arrives at the conclusion that in the cases considered there is no slipping of the fluid over the surfaces of the solid with which it is in contact. In the present paper a slightly different view is taken, and it is assumed that a certain finite (though possibly very minute) amount of slipping takes place, and that it forms an essential feature in the phenomena. The various cases considered by Von Helmholtz are treated on this assumption, and in some respects extended. In all cases the results differ from those obtained by Von Helmholtz by a factor l/d; where l is a linear magnitude measure the "slip" namely $B = u/l$, and d denotes the distance between the plates of the air condenser, whose capacity per unit area is the same as that of the opposed surfaces of solid and fluid. For example, by comparison with Wiedemann's experiments Von Helmholtz infers that for certain solutions of $CuSO_4$ in the pores of a clay vessel $E/D = 1{\cdot}77$, where D is the E.M.F. of a Daniell cell. On the hypothesis adopted in the present paper the inference would be that $\frac{E}{D} - \frac{l}{d} = 1{\cdot}77$. This involves two unknown ratios. No such definite conclusion can be drawn, but it is evident that the phenomena are consistent even with very small values of E/D, provided l

* Abstract of a paper read before the British Association Meeting at Manchester September, 1887.

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be a sufficient multiple of D and *d*. Since D is a quantity of molecular order of magnitude (comparable with 10^{-8} centimetres) the value of *l* may still be so minute as to render the effects of slipping quite insensible in such experiments as those of Poisenille. They come to be of importance in the cases at present under consideration only in consequence of the relatively great forces due to the fall of potential along the course of the current, which act on the outer electrified layer of fluid and attract it over the surface of the solid.

CORRESPONDENCE.

SPRINGS ON TELEGRAPH WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think that if some of your correspondents who are advocating the use of springs for telegraph wires had had some experience in the erection of heavy overhouse cables, they would find that they are not necessary. Nothing at reasonable cost will provide against such damage from snow and wind as was experienced in the snowstorm of last December; but for all ordinary strains the elasticity of good copper and iron is sufficient, if not destroyed by the process of "killing."

For example, if two No. 7/14 strand iron wires be erected parallel with one another in a span of 250 feet, and one loaded with a cable which is heavy enough to increase the dip by 5 feet in the centre of the span, it will recover its normal position upon the removal of the load, and become again parallel with the other wire. That this elasticity is not destroyed by age is shown by another case, in which a cable suspension wire (which had been erected some years), upon the removal of its cable, rose and put eleven wires which crossed it above in contact. This elasticity, moreover, prevents the alteration of the dip with temperature in proportion to the known rates of expansion and contraction of the metals.

In a span of 250 feet the difference in the dip between winter and summer is but a few inches, if the wire be set up without "killing" and well within the limits of its elasticity.—Yours, &c.,

F. HIGGINS.

17, Cornhill, E.C., Oct. 31st, 1887.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Let any of your readers stretch a cotton thread across the table, say between two chair backs, and then let a heavy knife, such as a carving knife, fall across that thread. If the thread is tight enough the falling knife will cut it asunder. It is easy to make the thread so tight that it will be cut, or so slack that it will not be cut.

Now let your readers join to each end of the thread a short length of elastic, and secure the latter to the chairs, straining the thread to the same minimum tightness as enabled the falling knife to cut it before. Will the same knife cut it now? No. Why not? The reason is self-evident. The elastic, by increasing the extensibility of the thread, enables it to yield and save itself.

The thread is the telegraph wire, the elastics are the regulator springs, the knife is the falling tree branch.

By increasing the extensibility of the catenary, the regulators render it correspondingly more secure against catenary loads generally, whether sudden or continual, whether loads of snow, ice, hailstorms, windstorms, falling trees, or any or all of these combined.

The increase of extensibility afforded by the particular regulator which I recommend enables the line wire with regulators to withstand *double the load* (sudden or continual) that the same line wire without regulators can bear.

This increase of extensibility virtually doubles the strength of the line without doubling its actual strength. The breaking stress of the 100lb. copper wire, for example, will be 330lb. in any case, whether with or without regulators. But that breaking stress in the wires as now hung would be caused by half the load that would cause the same wires to break if regulators were furnished.

If Mr. Preece were to urge that doubling the virtual strength of the wires, though a decided gain, is not a sufficient gain to justify even the extremely moderate cost of the regulators, his contention would be intelligible, though not sustainable. But he writes as though the storm stress on a tube of frozen snow would be the same stress with as without regulators (which is a great mistake), and he says the springs "will not be of *any service whatever* in preventing the wire from breaking." To sustain his proposition is to controvert laws of force, as your instructed readers will see for themselves.

Mr. Preece remarks that my invention is not novel. According to King Solomon, nothing under the sun is novel. But it was quite novel to me when I invented it, and evidently novel to Mr. Preece when he heard it from the lips of Sir F. Bramwell on the 4th Sept. at Manchester; else Mr. Preece would not have urged at first blush that it necessitated cutting the wire at every post.

I agree with Mr. Charles Bright, jun., that it is not improbable such an idea may have occurred to telegraph engineers before; but it is noteworthy that since this discussion was commenced at Manchester by Sir F. Bramwell no telegraph engineer has claimed the invention. I can only surmise that if any engineer conceived the idea during what I may call the "iron age" of telegraphy, he would soon find, as I found, and as Prof. Perry has since stated, that the springs were too clumsy and costly to be generally admissible. We are now at the beginning of the "copper age," when the same drawbacks of clumsiness and costliness no longer confront the inventor.

I did not aim at stopping the humming of the wires, but Mr. Bright is right in pointing out that the automatic grippers will have that effect. And I stated the same thing in reply to a query in the *English Mechanic* last week.

Mr. Preece is right in stating that my regulators would cause more snow to accumulate, for each spring would carry a snowtuft; but he fails to show how this could possibly "magnify the evil." He cannot mean the evil of excessive stress; for as to the *mechanical* condition of the catenary, it is plain that the snow wreaths on and about the insulators produce (whether greater or smaller) no appreciable stress. It is the snow on the *span*, not the snow on and about the *posts*, which adds to the stress so powerfully during gales. And it is evident that the wire with regulators would gather on its span no more snow than the wire without regulators.

Then as to the *electrical* conditions during a snow covering. These are somewhat *improved* by the use of the regulators; for, by the present system, the wires, being fast bound to the insulators, are necessarily enveloped in those wreaths of snow which not only collect on each insulator, but which frequently also bridge across the space between insulators, and thus tend to conduct cross currents between the line wires. But, as your readers will have noticed, the "bow" (as Mr. Bright calls it), or slack line wire between the small extra insulators, of my patent is bent *sideways* and *upwards*, for the express purpose, mainly, of making the line wire avoid the vertical plane of the springs and insulators, so that the line wire may follow a path quite *above* and *clear of* the snow wreaths.

Of course snowstorms will occur of such severity as occasionally to neutralise more or less this particular improvement; but in the greater number of snowstorms the line wire; with regulators will be more free of snow about the insulators than the line wires as at present hung.

My invention is designed to render the lines twice as secure as now against snowstorms and falling trees, also to entirely prevent chafing and leakage at insulators. Does Mr. Preece regard snowstorms, falling trees, chafing and leakage as "imaginary troubles"?

I may take this opportunity to point out to telegraph engineers that the spring regulator has all the advantages without the disadvantages of a *shackle*. Also the handling by the linesmen of the brittle-skinned copper wire is rendered less rude and not less rapid by my method of erection.

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TABLE OF DIPS, STRESSES, EXPANSION AND STRETCH OF A 100 YARDS SPAN OF COPPER LINE WIRE AT VARYING TEMPERATURES.

Coefficient of Expansion = ·00001 per deg. Fahr.
Modulus of Elasticity = 14,500,000lbs. per inch of sectional area.
Minimum Factor of Safety = 4.

Column A refers to copper wire weighing 100lb. per mile, *i.e*, ·0189391b. per foot, having a sectional area = ·00493in., and diameter = ·079in. Breaking stress = 330lb. Elastic limit = 165lb.

Column B refers to ditto 150lb. per mile, *i.e.*, ·028409lb. per foot, having sectional area = ·00735in., and diameter = ·0967in. Breaking stress = 495lb. Elastic limit = 247·5lb.

Columns marked * show what the dips, stresses, and catenary lengths would be if the wires were absolutely inelastic. These * columns agree very nearly with Mr. Preece's tables, reckoning from 22deg. Fahr. as datum. If * stress items (which relate to 100lb. wire) be multiplied by 1·5 they will give * stresses for 150lb. wire.

Temp. Fahr.	Dip.			Stress.			Catenary Length.		Normal length of wire unstretched.	Expansion reckoned from 22deg. Fahr. as datum.	Stretch.
	A.	B.	*	A.	B.	*	—	*			
deg.	ft.	ft.	ft.	lb.	lb.	lb.	ft.	ft.	ft.	ft.	ft.
22	2·5842	2 5842	nil.	82·5	123·75	nil.	300·05936	nil.	299·7134	nil.	·3459
40	2·9047	2·9047	3·571	73·4102	110·1153	59·735	300·075	300·11336	299·7674	·054	·3076
58	3·2692	3·2692	4 339	65·4219	98·13285	49·189	300 0953	300·16736	299·8214	·108	·2739
76	3·6635	3·6635	4·9903	58·2309	87·34635	42·7922	300·1193	300·22136	299·8754	·162	·2439

It is with regret I find myself in apparent conflict with Mr. Preece; but I cannot, in justice to myself, or to mechanical science (the study and practice of which has more or less deeply engaged the best seventeen years of my life) accept even his *ipse dixit* as a true verdict.

I append a table of dips and stresses of copper wire catenaries at various temperatures, which, if Mr. Preece will compare with his own, will show him whether he has been justified in publicly declaring that I have not realised the conditions that determine the stability of a telegraph wire.—Yours, &c.,

FRANK CAWS.

Sunderland, 31st Oct., 1887.

THE PROPOSED ASSOCIATION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to see that the proposal to establish an Association of Electrical Engineers has been received with such evident favour by so many of the large firms both in London and the provinces. This practical unanimity of opinion not only shows the need of such an association, but also argues well for its success, if started. The electrical industry is comparatively new, and is growing so rapidly that it needs competent and careful watching to preserve it from disaster. Inexperience on the one hand, and unprincipled speculation on the other, have told their tale on the confidence of the public. A period of universal depression of trade has again handicapped the youthful industry, and an unhealthy trade competition has still further tended to depress it in this country. But yet electricity as a medium for lighting and the transmission of power is steadily gaining ground. The trade is to some extent recognised as a branch of mechanical engineering, but it is not yet sufficiently defined. There is too much tendency to look upon the electrical engineer as a scientist rather than a practical man, and I regret to say that oftentimes he is neither. Now the Society of Telegraph-Engineers does not pretend to regulate trade questions in any form; and its composition and general method of procedure make it eminently unsuited for such action. It is a scientific society. The association, however, would, I take it, be essentially representative of the firms and the men immediately engaged in heavy electrical engineering. Its proper functions would be the discussion of trade matters in their commercial bearing, and the exercising of a general supervision over the welfare of the industry. The association, moreover, speaking with the voice of the profession, would carry more weight than a few firms, and harsh legislation would no longer be possible. A method of determining the output of any dynamo or motor in general terms is very desirable, and would do much to reconcile the apparent disparity of prices now existing. This could only be done by such a representative association; indeed, the field for the usefulness of the proposed Association of Electrical Engineers is very large, and I hope to see it placed on a satisfactory basis very shortly. I shall be pleased to do all in my power to further its formation.—Yours, &c.,

ALBION T. SNELL.

24, Glycena-road, Lavender-hill, S.W.

DEAR SIR: Your suggestion of initiating a scheme for forming an Electric Light Convention in England is a good and seasonable one, which many members of the profession have at least talked about. The sooner it is got to work the better for all of us.—Yours truly,

HENRY M. SAYERS.

Dovedale, Moreton-in-Marsh.

Lord Edward S. Churchill presents his compliments to the editor, and having seen in *The Electrician* his suggestion for forming an Electric Light Convention, writes to say he would be willing to join.

Messrs. Paris and Scott, after expressing their approval of the movement, add:—"We think that it should concern itself more with the business aspect of electrical engineering, which need in no way mean an interference in one another's business, but solely to help with advice and practical knowledge any member in a difficulty."

ON ELECTRIC STREET CARS, WITH SPECIAL REFERENCE TO METHODS OF GEARING.*

BY A. RECKENZAUN, C.E.

(Concluded from page 523.)

FRICTION GEAR.

There is something quite fascinating in friction gear. It offers the advantages of simplicity, noiselessness, and theoretically a high efficiency; but as regards certainty of action and durability, it occupies a low position in the scale of appliances for the transmission of power. The late Prof. Fleeming Jenkin devised an apparatus a few years ago which he called "nest gearing," and of which great things were expected, and, indeed, it was regarded as the most perfect frictional gear ever invented.

Prof. Jenkin arranged several rollers within a ring; these rollers were in contact with a central friction wheel which was attached to the motor, and the outer ring was connected to the driven object. It is well known that in a pair of friction

* Paper read before the American Institute of Electrical Engineers, New York, Sept. 20th, 1887.

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wheels when running together, the contact surfaces are exceedingly small, the pressure must be great, and consequently there is a rapid destruction of the said contact surfaces. Now, by placing a number of rollers within a ring, not only are the contacts multiplied, but there is a perfectly balanced pressure upon all the working parts. This kind of gearing, made of the best materials and of the finest workmanship, has been applied to the telpher line at Glynde. Its efficiency was tested and found to be somewhere near 95 per cent. In the case of telpher lines the motor and its attachments are well out of reach, suspended on tall posts, therefore dust and dirt can be absolutely excluded. The energy transmitted between the electric motor and the driving wheels averaged only 1·5 horse-power, and yet with all these advantages and the great care exercised in its construction and use, this gearing refused to act after a comparatively short space of time. The experiments were watched with intense interest by all who made mechanical science their profession, and especially by those who were seeking effective means of transmitting motion from electric motors. After a number of exhaustive tests, apparent improvements and modifications, the inventors of this nest gearing pronounced it a failure, and finally resorted to chains and cog-wheels. This fact, established after prolonged and most persistent efforts on the part of a number of the smartest mechanicians, should be a warning to all the advocates of friction gear for street car propulsion.

WORM GEARING.

Dissatisfied with the results of my early experiments I resolved to give worm gearing a trial. I collected all the data I could find in text books and from other people's experience. All the different authorities agreed on one point, and that was the efficiency, or rather the want of efficiency in worm gearing. According to various statements the *loss* with this mode of transmission was put down at from 33 to 75 per cent. This seemed to me a terrible waste of power; I was then, as now, engaged in the problem of utilising storage batteries for street car propulsion. Storage batteries were at that time in disrepute generally, and as for putting these cumbersome things upon a car, the very idea of it was ridiculed by conservative-minded men. Certain would-be experts published their views on this subject, and they endeavoured to prove mathematically that the battery could scarcely hold sufficient energy to propel its own weight, and that more than 50 per cent. of the power given by the charging dynamos was lost in the process of transformation. If they had known at the time that I proposed to introduce another energy-consuming apparatus in the form of worm gearing they would have declared me a lunatic. There were, however, quite a number of extenuating circumstances which encouraged me to pursue this question. I knew, from experience, that the storage battery, if properly constructed and used, could return more than 70 per cent. of the energy expended upon it; I knew also that a certain type of cell could propel several times its own weight at a speed greater than that of a horse car.

With regard to worm gearing, I found that this method of transmission was used for hoists and for actuating machine tools, and that in some cases it has been working for twenty years without requiring any expensive repairs. During all my researches I failed to discover any reliable data on the construction and use of a worm which had such a steep thread that the worm wheel could cause it to revolve. I did not come across any publication with figures to show the efficiency of gearing where the worm shaft revolved at a very high velocity whilst transmitting considerable power. Just at that time the valuable researches of Profs. Thurston and Kimball and Mr. Beauchamp Tower, on the subject of friction and lubrication, were published, and these revealed the fact that all the long established laws on friction were entirely wrong. The experiments of these scientists proved conclusively that the coefficient of friction varied with the velocity, and that it decreased up to certain limits, with an increase of speed between lubricated surfaces.

Furthermore, it has been demonstrated that the coefficient of friction between lubricated bearings is not ·1 or ·2, as so frequently stated in text books, but ·003 and less, and that even with moderately bad lubrication it amounted to only ·01. All these, and other considerations encouraged me in the belief that there is a fruitful field for further investigation, and I designed a set of worm gear of the following dimensions:—Steel worm, turned and polished, 6in. in diameter, 6in. long, treble thread of 2in. pitch; worm wheel of phosphor bronze, trimmed teeth, $15\frac{9}{22}$in. diameter, $3\frac{1}{2}$in. face, 24 teeth. Ratio of gear, 8 to 1. The worm was fitted to the spindle of an electric motor, and the worm wheel attached to the axle of a street car, which was supported on a frame with bearings to keep the wheels off the ground. When running empty, with the worm out of gear, the motor took 6 amperes of current, and when put in gear, but without any other load, 7·75 amperes were used to drive the apparatus at the same speed. Prony brakes were then applied to both the motor shaft and the car axle, and the power was measured on each at a given E.M.F., current and speed. The efficiency of the gearing was calculated by dividing the horse-power given off on the axle by that measured on the worm shaft, and we found that the useful effect increased with the speed, viz.: at 300 revolutions of the worm it gave 80 per cent.; at 520 revolutions, 81·1 per cent.; at 676 revolutions, 85 1 per cent., and finally at 770 revolutions, 87 per cent. These results were then compared with the electrical energy supplied to the motor in each experiment, and they were found to correspond very closely, after the usual electrical losses in the motor itself were deducted. The mechanical horse-power was thus checked by the electrical horse-power, and at last I applied the well-known formulæ for the efficiency of worm gear, which is given in every book on mechanical engineering—

$$E = \frac{\cot\theta}{\cot(\theta-\phi)} = \frac{1-\mu\frac{p}{2\pi r}}{1+\mu\frac{2\pi r}{p}},$$

where θ is the angle of the worm thread,
μ the coefficient of friction,
r the radius of the worm, and
ϕ the angle of repose between metal and metal;
E gives the efficiency of the pair.

If the coefficient of friction is taken at ·015, then the efficiency must be 87·5 per cent.

By means of the above tests and the formula we can find the coefficient of friction for the various speeds.

When this apparatus was attached to the car, I found that it required less current to propel it than it did previously with the chain gear, therefore I have always since used the worm gear. Mr. Holroyd Smith tried it recently on his cars, as already stated, and he told the meeting of the Society of Arts, in April last, that he "found it the most effective mode of transmitting the power from the motor spindle to the axle, taking all points into consideration."

With these remarks closes a short and incomplete chapter on gearing. There are other kinds of gearing which I have not touched upon. I cannot do better than to leave the subject in the able hands of members present, who, I hope, will supplement, criticise and amend the observations herein set forth, and thereby add to the general knowledge of one of the most important topics of the day. We are continually advancing; every hour marks a step forward in the direction of success. The grand general principles of the electrical transmission of energy are now well understood, but there are yet many other ways of adding to the sum of human knowledge, as for example in following up the details of construction, every one of which will add in some measure to the final triumph. Even by relating our mistakes and failures we serve a good purpose. "There are," said Prof. Silvanus Thompson, "half-forgotten observations, unconnected, unexplained, and often exceptional in character, every one of which has a significance of its own—residual phenomena, every one of which is, to the scientific man, of a value beyond price. He who investigates them patiently may find a clue to their meaning, and reap a rich reward from them. They are the finger-posts in the high road of discovery."

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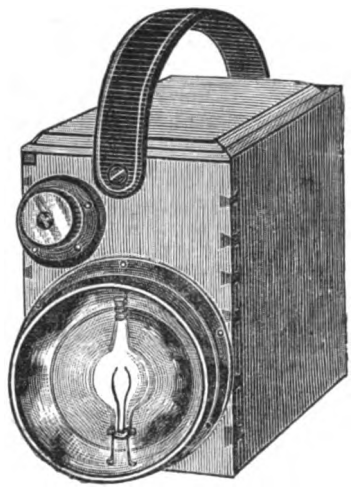
PITKIN'S PORTABLE LAMP.

We have been favoured with the following description of the Pitkin Portable Lamp, which is illustrated in the adjoining figure:—"These lamps are intended for use in coal mines and other places where explosions may be apprehended. They are the invention and manufacture of Mr. James Pitkin, of 56, Red Lion-street, Clerkenwell, who has spent some years in perfecting the details of their construction. Each lamp is of the form shown in the engraving, and weighs approximately 7lb.; they are, however, easily carried by means of a strong leather handle passing across the top from front to back. When the cells are fully charged the lamp, which is of four candle-power, will burn from twelve to eighteen hours, according to the degree of incandescence at which the lamp is burned. This can be conveniently regulated by means of a switch (shown upon the front of the box), which not only turns the light on and off, but by sliding over a platenoid wire of small diameter inserts more or less resistance in the circuit. The glow lamps are of the Swan type, and are suspended from above by means of a spiral spring, secured to a metal loop, fused into the glass globe forming the lamp. They are further held in position by means of the screws passing through the case and hooked to the under side, these also form the connection between the lamp and the cells. Each cell has eight small lead plates with a projecting edge forming a trough, and projections or pins of lead at regular distances,



which hold the storage material firmly to the surface of the plates. The whole arrangement is well designed and substantially made."

DISCUSSION ON PROF. FORBES'S METER AT THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Prof. Forbes's current meter (which was described in these columns on September 23, page 421) has so far met with a very warm welcome in the United States. It will not be necessary to reproduce the paper which Prof. Forbes read before the American Institute of Electrical Engineers, which was practically the same as that already read before the British Association. But the following abstract of the discussion which ensued will be read with interest:—

Prof. FORBES: I would like to add one or two points about the instrument. In this instrument there is one part which I have not described to you, and perhaps before I describe it I ought to let you see it working. I am starting it with a current of 11 amperes. It takes a little time to get up its full speed and a little time to lose its full speed. I have shown this lighter form of wheel work, and I am making it even lighter than it is in the instrument which is being manufactured now. This instrument has a good deal of metal work, much more than in any of the instruments which I have been using before, and the mass of metal absorbs so much heat that it went on for a considerable time after the current was broken. Now this might suit the suppliers of electricity very well, but it would not, of course, suit the consumers, and one must defer to both sides. I do not want the meter to act in that way, and I find that by reducing the metal work as much as possible that difficulty is taken away. There is another point about this instrument which I have not shown you or spoken to you about. It is an arrangement which is attached to it for lifting up the mica vanes against a fixed stop above. I have moved the stop away at present. That lifts the mill wheel up against the stop and enables us to carry it about with safety. That is to say, I must make one reservation—there is fear of danger if it passes through the New York Custom House (laughter.) I brought in a lot of instruments, and after I saw a little of what the Custom House people were doing it sickened my heart so much that I let them lock the instrument up and put it in the public stores. I had worked six hours that morning like a slave, doing their bidding, and by the time it came to me I am sorry to say that many of the things were in a sad state. You will notice something hanging to this instrument (pointing to another). That was an extremely delicate spiral spring which was attached to one of these mill wheels, acting simply as an amperemeter, not arranged for registering the consumption, but measuring the rate at which the current is passing through the conductor. That instrument is quite disabled, and others too. I have also some diagrams here. Here are actual examples of some of the readings of these amperemeters, and I have sometimes taken them under different conditions. I have, for example, got the instrument with the clockwork in, and without the clockwork, showing the amount of friction, and I may tell you this, that it looks as if the wheelwork there would cause a considerable amount of friction which has to be got over. That friction is a mere nothing compared with the friction of the air which is circulating in these convection currents which are created. There are three frictions entering in the action of the instrument. First, there is the air friction in the currents of air, which is the chief source of friction; secondly, there is the friction of the jewelled cup on the point; and, lastly, there is the friction of the wheel work, which is far less than the friction of the jewelled cup upon the point. That is what one of these diagrams shows. Another one happens to show the effect when the apparatus for fixing the mill wheel is taken out. Another one may be of some interest to you. It was taken from the instrument when it was in an experimental stage. I varied the distance of the vanes from the conductors, and I used it at $\frac{1}{16}$, $\frac{2}{16}$, $\frac{3}{16}$, and $\frac{4}{16}$ of an inch. You might expect that the nearer it was to the conductor the greater the velocity would be of the given current. That is not so. It then creates friction by pulling the air from the surface of the wire when it was too near. Three-sixteenths of an inch was found to be the most suitable distance.

Dr. VANDER WEYDE: If you use a shade it would seem that when the apparatus is in operation a little while the air will be heated and the ascending force would diminish and become very small, at least when the air was considerably heated in the glass shade. To correct that nothing would be easier than to make an opening in the top of the glass shade to let the hot air out and keep the surrounding atmosphere more uniform. When the apparatus has been in operation for some time, so that the air becomes heated which surrounds it, the indications would become a great deal less. I wish to do justice to Prof. Forbes for the ingenuity of the apparatus, and the remark I made is only for the purpose of suggesting something which may make the apparatus more perfect.

Prof. FORBES: These are very suggestive remarks that come from Dr. Vander Weyde, and of course they occurred to me during the process of the experiments. There is one lesson that I have learned from this instrument, which is that you cannot calculate on what is going to happen with a convection current (applause). I have been as sure as possible, over and over again, when I was making a minute change in the instrument, that I knew as well as possible what it was going to do, and it never did it. Dr. Vander Weyde suggests that when the air at the top of the shade gets heated the instrument will go slower. The only answer that I can give to it is that it does not. It goes perfectly continuously, however many hours that I have it at work. He suggests that a hole should be made in the top to keep it cool. Nothing in the world will ever induce me to let a hole get into that mechanism any more than I would let the works of my watch be exposed to the open air to get dust into them. But it is quite unnecessary, for it goes any number of hours at a perfectly constant rate, even when the top gets hot. It is remarkable that the first person who has spoken at this discussion has raised the first objection which every person who has ever spoken to me about it has raised, and that is that its indications will depend upon the external temperature; that when the external temperature is high it will go quicker. This is the only one thing, however, in which practice does agree with theory in regard to convection currents. The theory of the thing is perfectly simple. The moving force is the *difference* of temperature between the conductor and the external air. It does not depend in the least on the *absolute* temperature of the place, it is only on the heat that is being generated in the conductor, and it is the difference of temperature created therein and the external air which gives you the moving force. It is a matter of indifference whether you start with a temperature of 30 or 100 degrees. As a matter of fact, the indications in a warm atmosphere and a cold atmosphere are identical. I may forestall the question that is going to be asked immediately, whether the barometer has any effect. I may say that I have not had the instrument under an air pump to test it, but I have tested it day after day, and I have seen no perceptible variations.

Dr. VANDER WEYDE: What becomes of the heat which is continually generated?

Prof. FORBES: It is radiated from the surface of the glass. A great deal collects at the top. A fixed temperature is arrived at of course, and the heat which is being created is all radiated from the surface of the glass.

Mr. FRANK L. POPE: The amount of heat which is generated by the action of the current is not very great at the most, and as it gradually collects in the top of the glass it is probable that before the hot air extends down far enough to affect the operation of the instrument the radiation has become great enough to carry away an equal amount of heat with that which is being generated, and the temperature from that on is stationary. The balance is brought about before the currents of air are affected sufficiently to affect the operation of the instrument.

Mr. MAILLOUX: There are some other points which I would like to bring forward. One point is about the friction of the apparatus. I would like to know whether the calibration of the apparatus does not depend for its constancy on the friction of the apparatus remaining constant as nearly as possible; and it also occurs to me to suggest that the friction of the apparatus may have a great deal to do with its sensitiveness as an

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integrating instrument. In other words, if there is very little friction, it is quite likely that the inertia would be greater, and its momentum once obtained would tend to carry it over, so that if there were any abrupt changes in the current it would not so readily respond to them. So that if we were to draw a curve of variations of current it would in reality not follow that curve closely but only partially, introducing a quantity in the result which would be the analogue of self-induction with an ordinary apparatus. Now there is another point. We all know that in order to obtain heat from a conductor we must have a certain amount of resistance, and I would like to know whether the amount of resistance that has to be introduced in the wire (which I presume is iron from its appearance) is of material consequence, whether it would figure at all as n element of resistance of the whole circuit, and also whether, by virtue of its resistance or of its position, it would introduce any variation which has been called impedance in the circuit in consequence of self-induction or anything like that.

Prof. FORBES: The first question, as to the effect of the constancy of the friction—whether the speed of the instrument depends upon the constancy of the friction of the solid parts?—and the second question I had better take in connection with it, which is, whether that friction of the solid moving parts renders it less sensitive? First, we have to consider whether, after the lapse of months or years, when the mechanical parts of the instrument are not in such good order as when it was started, its readings will be as accurate as they were at the beginning? and in the second place, will it be so ready to start with a feeble current with the friction of the wheel work as without it? I have already said that the most important part of the friction in that apparatus is the air friction; but that is especially so in the case of a larger current. When the currents come up to the average strength or greater, the air friction is out of all comparison the greatest friction that we have in the instrument. At any time the friction of the wheel work, incredible as it seems to most people at first sight who are not accustomed to thinking much of the subject, is but a fraction of the friction of the jewelled cup upon the pivot. You must remember that the first wheel of the wheel work is rotated at only one-tenth of the speed of the mill wheel, and its weight is extremely light compared with the weight of the mill wheel, and the friction of the first wheel is therefore very slight indeed; and when you come to the second wheel, its speed of rotation is diminished tenfold, and its lightness is small compared with the mill wheel. I was told to expect this by a great friend of mine, whose name I ought always to mention in connection with this instrument, Mr. Augustus Stroh, who assisted Sir Charles Wheatstone in all of his celebrated inventions, and who has assisted me in all this work, and there is no man more capable of giving such assistance in the mechanical details of an instrument like this. I had intended to make a German pun, a thing I never did in my life before, and should have done so if it were not for the earnest objections of Mr. Stroh, and call this a Strohmeter (applause). That is the way that the friction of the apparatus comes in. It is very slight indeed compared with the air friction, except with very feeble currents indeed. The result always, then, has been that what I call the ratio of speed to current was constant whether the friction were a little more or a little less, but that it did not start quite so easily with extra friction, and I have no doubt that if the wheel work were to get seriously out of order, and we were to have very much more friction, it would not be so sensitive to a single lamp; but at higher speeds there would not be the slightest difference in the indications. For example, to show you how that works, I have two diagrams giving you the ratio of current to speed when different currents were passing through with the clockwork attached and without the clockwork attached. You would notice in these that with the clockwork attached it did not start with so small a current; but when the instrument was once in working order, from one and a-half amperes or so, or upwards, the two lines of ratio of speed to current were identical. Prof. Forbes then went on to say that experiment showed no difference in the behaviour of the instrument with alternating currents.

Mr. S. S. WHEELER: I would like to ask what the resistance of the coil used is?

Prof. FORBES: Nearly a tenth of an ohm.

Mr. SHELBOURNE: Now, in regard to the first question that was asked by Prof. Vander Weyde in respect to making a hole in the top, does it not appear that the apparent inaccuracy of the instrument in registering light currents and in getting its rate may be due to the generation of heat at the commencement, and that heat accumulating in the top of the instrument and heating the glass, it would arrive at a point where there is an equation between the generation of heat by the wire and the radiation from the outside of the glass? I simply suggest this, and I ask the professor whether he has ever tried in making instruments, instead of making the whole of the cover of glass, to put a dome of copper or some other conducting metal upon it, so that the air which rises and accumulates at the top may sooner reach that equation of radiation from the outside of the instrument with the generation of heat which operates the mill wheel?

Prof. FORBES: I really do not think that practically it is very important. Otherwise, I think the suggestion that was made very likely would be good—using a metal shade. Of course I have had numerous changes in shades. I have tried a shade which was nearly all metal. But I found this shade before you the best one I have used up to the present time. However, I think it is quite likely that the suggestion just made might be a good one—that a metal shade would be fully as good as the other—might be better, and might make it a little more sensitive perhaps. I think there may be a good deal in what you say.

Mr. WETZLER: I am a little interested in knowing whether any experiments have been made to determine the best angle and shape of the vanes of the mill wheel, and if the shape determined on there has been found to be the best.

Prof. FORBES: As to the angle, I have committed the grossest folly that a man with the experience I have had with this meter could commit—I have trusted theory. I have been positively certain that an angle of 45deg. must be the best. I am sorry Mr. Wetzler has drawn this confession from me, because it is really the only respect in which I have trusted to theory. As to the other points, the shape of the vanes has been the source of endless experiments. I made an enormous number of changes before I arrived at this shape, and even little details in the shape have come from experiment. I made hundreds of vanes in the experimental stage, and I am pretty sure that if that type of mill wheel is to be used the vanes are of the right shape.

Mr. WESTON: I do not know that I can say very much more than has already been said in regard to the instrument by Prof. Forbes. I think it is an extremely ingenious and beautiful instrument. There has been already a great deal of time and a large amount of money spent on electric meters for direct currents, and I can say with Prof. Forbes that I do not think we have had any current meter of any value whatever. The electro-chemical system in use by a very prominent company here was put out with a great deal of confidence with the results to be obtained from it. I think any one looking at the principles involved would condemn it from the start. You are to take a small fraction of the total current, and a very small fraction indeed, and pass it through an electrolytic cell, the character of which varies from time to time, so that the resistance is never fixed, and pass the bulk of the current around a resistance which is practically fixed. The change in the resistance of the metal would be but a small proportion of the change in the resistance of the electrolyte. Now in such an instance as that you are measuring a very small fraction of the current passing, and whatever error you have you are multiplying that error by that fraction. If you are measuring 1-1,000 you are multiplying your error by 1,000. Any one who has had much to do with electro-metallurgy knows that the cells are constantly changing; that to keep the deposit regular and uniform, to keep the resistance of the solution uniform, they must be constantly attended to. There is not an electroplater in the country who does not once in awhile go in and stir up his baths. Such an instrument is of no real value. We may therefore dismiss those instruments entirely from consideration, I think. A great deal of work has already been done on magnetic instruments; that is, instruments which depend upon the magnetic attraction of the current through a wire, or the current through a wire going around an iron coil. In those instruments we have all the defects which have been referred to as being possible to exist in this instrument here to-night, manifested a thousand times more, with numerous others that do not exist in this instrument at all. I can speak feelingly on the matter, because I have given a great deal of attention to it, and have thought once or twice I had something very good, and have been finally obliged to abandon it. Mr. Weston then described some experiments which he had made upon a meter of his own bearing a general resemblance to the Ferranti type. He had not, however, been satisfied with the result. The description is not intelligible without the aid of the sketches made on the blackboard. He continued: I do not know whether Prof. Forbes has done any work on the friction between a mass of metal revolving in mercury or not.

Prof. FORBES: I did a good deal of that at one time.

Mr. WESTON: If you did you will understand the difficulty. Nothing was accomplished. I may say, however, that it has already given rise to a very neat form of current instrument, in which, instead of having the disc rotate, it was fixed, a large index being brought out from the disc, in which case it was absolutely proportional to the number of lamps in circuit. For a station ammeter I do not know of anything that equals that to-day. It shows the current when there are 300 or 400 or 500 on, just as it shows one lamp by itself. Prof. Forbes has got here the simplest instrument that I think could be built. I do not see how you could improve it very much except in detail. The principles are correct, and I must congratulate him very highly indeed upon the success of the instrument.

Mr. RIES: After Prof. Vander Weyde's suggestion, which was the first one made this evening about the hole in the glass shade, it occurred to me that perhaps another principle besides those mentioned by Prof. Forbes might be utilised in the construction of a meter of this class. Prof. Forbes mentioned electro-chemical action, electro-magnetic action and caloric, or heat, as the basis for a measuring instrument of this kind. Now, if we could obviate the friction due to the revolution of these vanes in the air, and place them in a vacuum, like Crookes's radiometer, and instead of utilising the principle of heat use that of light to give motion to the vanes, I do not know whether that would not make a very delicate apparatus. It suggests a different direction in which to work. You might perhaps take these vanes and place them in a dark cell, surround them with a strip of platinum wire or carbon filament, and use the variations in light to change the number of revolutions per second, and that could be recorded by an apparatus similar to that used by Prof. Forbes. I simply offer that as a suggestion.

Mr. HOWELL: I was very much surprised to hear what Mr. Weston said. I am surprised that he does not know that there is a temperature correction in the Edison meter. The Edison meter has been in use industrially for five years, and I say without hesitation, and I am in a position to know the opinion of the practical men who are using the Edison meter, that they think a great deal more of it to-day than they did before, and the more they use it and the more they know of it the better they like it. There is one thing about that meter of Prof. Forbes which recommends it to me as the result of experience with instruments sent out for general use. There is one peculiarity about every American electrician, and that is, he has got to know what things are made of, and if you do not show him he will find out for himself. Now, that instrument shows itself. You can look at that and see what every part is, and you do not

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need to take it apart. I have sent out a great many instruments. The first thing a man does with them is to pull them apart and see what they are made of. There is no necessity for pulling that instrument apart; you can see all about it. There is one thing I would like to ask Prof. Forbes, and that is the effect of lowering the shade? I see he has a shade there very much higher than the instrument apparently needs. I would like to know if that is necessary to allow for air circulation?

Prof. FORBES: Yes; it is more sensitive with a higher shade. That is about the limit. I have gone through dozens of shades to see what is the right size and shape, and that is the one I have fixed upon.

Mr. CROCKER: I ran roughly over the amount of heat that would be generated in Prof. Forbes's instrument, and it came so high that I should like to go over the figures now and see if they are right. He says the resistance is under a tenth of an ohm. Assuming it to be the tenth of an ohm, 20 amperes would give two volts drop, and two volts and 20 amperes would give us 40 watts; and 40 watts multiplied by 44·2 is about 1,760 foot-pounds, and 1,760 foot-pounds gives us two heat units, roughly. That is, two pounds of water will be heated one degree Fahr. in one minute by Prof. Forbes's resistance when it is working up to its full capacity of 20 amperes. Two pounds of water heated one degree is equivalent to eight pounds of air heated one degree. I believe the specific heat of air is a quarter that of water. That is my recollection; it may be wrong. There are eight pounds of air heated one degree Fahr. Now the contents of that shade there are approximately a quarter of a cubic foot. Therefore, the heat produced in that shade would be fifty times as much as it would be in one pound of air—8 times 50 is 400, therefore we have 400 degrees per minute. It is a very high figure. I cannot believe that it is right. But we know that the capacity of the amount of air in that shade for heat is very small, and we also know that the amount produced in a tenth of an ohm by 20 amperes of current is quite large. Therefore, perhaps that figure is approximately right.

Prof. FORBES: I think perhaps it would be better if I might be allowed to answer the question after it has been written out by the shorthand writer. It is rather difficult to follow the point where we went from water to air, and the larger quantities, and to see that the figures were right. But I do not see that the quantity of air that is heated, or the quantity of water that is heated, has anything to do with the question. I would suggest that the speaker, instead of taking that line, would simply multiply and find out how much energy is used in the meter when 20 lamps are burning, and divide one by the other and get the percentage. Settle upon the percentage more than which you are not going to use and you have it. I should think very much over 2 per cent. or so would be very undesirable to use. It some cases it might go up to 3 or 4 possibly, but I should think as a general rule you would find 2 per cent. as much as one would care to use. The question of the number of lamps you use simply depends on what amount of energy you care to use.

Mr. CROCKER: I did not mean the efficiency of the apparatus. I did not mean that Prof. Forbes's meter used up any considerable fraction of the current. I merely meant to bring forward as an interesting point exactly how much heat is produced in the meter in a given time, and to calculate it as well as I was able to with the figures I happened to have in my mind.

Prof. FORBES: Then I would point out that theoretically you have to take in another point, and that is that there is continual radiation going on, and that during constant running there is no addition to the heat contained in the instrument. It arrives at a constant condition when the heat generated in the wire is equivalent to the heat radiated from the surface of the glass. From numerous experiments, both in Sir William Thomson's laboratory, and also by Prof. Tait, we have got at the constant of emissivity, the rate of radiation, and it is very easy to go on with the calculation a step further than done just now, and calculate what is the temperature which would be reached when the emissivity or radiation from the surface is equal to the heat generated from the wire. The problem looked at simply as a theoretical problem of interest can actually be worked out by going a step further than the speaker has just stated.

Mr. WHEELER: What is the approximate temperature of the meter after running a few minutes?

Prof. FORBES: Running at its full it is 120 degrees, perhaps.

Mr. WHEELER: Even at that low temperature it must get enough higher than the surrounding air to radiate 2½ heat units.

Prof. FORBES closed the discussion as follows:—I feel that this discussion has been of great value to all of us. Very interesting points have been raised, and I have heard suggestions which have given me great interest indeed. Of course, in working at this instrument one started from theoretical notions, but one gave them up very soon, and one had all sorts of resources at one's hand to vary the forms of these curves, some of which I have already shown you. I should like to show you the curves which I got when I first made this instrument. The curve ought to be simply a horizontal line. One of the curves which I first got was of about this shape (resembling the letter U), and yet I had the greatest hope even when I got that. By two changes I was able to reduce the line down to a horizontal, and there were numerous other changes. In the course of working that instrument out I learned more about convection currents than I knew there was to learn, and really one has power now to handle them as one pleases. I have no more remarks to make, except that I thank every one here for the pleasant discussion we have had this evening. I think it has been very instructive, and I have felt throughout the same kind, cordial sympathy that was shown in England. I did not expect to find everyone ready to look upon it in the way in which Sir William Thomson did, without any sign of regret that it happened to be done by another. I thank everyone here most heartily for the cordial way in which they have received this stranger (applause).

On motion of Mr. PENDLETON, seconded by Mr. F. W. JONES, a vote of thanks was tendered to Prof. Forbes, and the meeting adjourned.

ON THE PHYSICAL PROPERTIES OF A NEARLY NON-MAGNETISABLE (MANGANESE) STEEL.*

By W. F. BARRETT, Professor of Experimental Physics, Royal College of Science for Ireland.

In the early part of 1884 Messrs. Hadfield and Co., steel founders, of Sheffield, exhibited at the Institute of Mechanical Engineers specimens of steel which they had recently manufactured containing from 10 to 13 per cent. of manganese. Up to that time it was, I believe, the general impression among mechanical engineers that a steel containing more than 1 per cent. of manganese was practically worthless. Nevertheless, Messrs. Hadfield showed that samples of their manganese steel had not only very great tenacity, but combined the valuable property of toughness with extreme hardness, and that it also made very good castings. But to the physicist the most interesting property of this steel is the fact, to which Mr. J. T. Bottomley drew attention in this section at Aberdeen in 1885, that manganese steel is almost wholly unmagnetisable. After submitting a bar of this steel to an enormous magnetising force Mr. Bottomley determined the intensity of magnetisation thereby produced in the steel, and he found a permanent magnetisation of only 0·013 C.-G.-S. units per gramme. Ordinary steel has a number varying from 40 to 60 and even up to 100 C.-G.-S. units per gramme—that is to say, ordinary steel is capable of an intensity of magnetisation from 3,000 to 7,700 times greater than that of manganese steel; or if the intensity of magnetisation in a specimen of ordinary steel of average quality be 100,000, that of manganese steel is only 20.

It is obvious from this that manganese steel is a remarkable body, possessing properties of interest and importance alike to the physicist and to the mechanical engineer; it was desirable, therefore, to submit the substance to further investigation. Mr. Bottomley was good enough to let me have his bar of manganese steel for this purpose, and Messrs. Hadfield, at my request, endeavoured to draw some of the steel into wire, so that I might measure its electric conductivity and modulus of elasticity by traction. The drawing of manganese steel proved of much difficulty, and Messrs. Rylands, the well-known wire drawers of Warrington, obliged me by making the attempt, but could not succeed. Eventually Messrs. Hadfield succeeded, after many ineffectual trials, and in writing to me thus described the process they adopted:—

"As exceedingly good bending tests had been obtained with bars of the same steel when heated to a yellow heat and plunged into cold water, it was thought worth while to attempt a similar experiment with the rolled rods before trying to draw it down into wire. The rods were coiled up, heated to a yellow heat over a smith's fire, and then plunged into cold water. It was then easily drawn into wire, starting with No. 7 gauge, when it was drawn to No. 9 with safety. This drawing again took out the requisite ductility, and it was therefore necessary to again heat the wire and plunge it in the same manner as before. By doing this each time the wire was reduced two numbers of the gauge; there was no difficulty whatever in drawing it to any desired fineness, the only point necessary being that the wire must be heated sufficiently hot before plunging into cold water, or the wire would be still too hard. The colder the water the better the result."

It will thus be seen that sudden cooling increases the ductility and lessens the hardness of manganese steel—in other words, it anneals it, the opposite effect, of course, to that produced by sudden cooling in ordinary steel.

In this way Messrs. Hadfield furnished me with a few metres length of two sizes, No. 13 and No. 19 S.W.G. manganese steel wire. The wire was of two kinds, hard and soft. The latter was as flexible as soft iron wire; the former, on the contrary, was extremely rigid and hard. The *chemical composition* of the wire was as follows:—

Fe 84·96, Mn 13·75, C 0·85, Si 0·25, P 0·10, S 0·09 per cent.

Its *density* was 7·81, that of common steel wire being 7·717. Its *hardness* was such that it easily scratched steel, not hard-tempered. Exposed to the air manganese steel rusts rather more quickly than polished steel, but not nearly so quickly as iron. Careful experiments were made to determine—(1st) Its modulus of elasticity (Young's modulus) by direct stretching; (2nd) its breaking strain; (3rd) electric resistance; and (4th) its magnetic susceptibility. The results were communicated to the Royal Dublin Society in a paper read before that society in December last. These results, together with some additional experiments on the temperature variation of electric resistance, are briefly as follows:—

The modulus of elasticity was determined by suspending a length of 4 metres of the No. 19 wire (0·98 millimetre diameter) from a suitable clamp, the flexure of which under the maximum load used was tested and found inappreciable. An initial weight of 2 kilo-

* Paper read before the British Association Meeting at Manchester, September, 1887.

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grammes was kept on to straighten the wire, and additions of 10 up to 40 kilogrammes were made. With the maximum load there was no set, the index returning accurately to zero on the removal of the weights. Three series of experiments were made, embracing some thirty observations, the mean of which gave 16,800 kilogrammes per square millimetre, or $1,680 \times 10^6$ grammes per square centimetre as Young's modulus for hard manganese steel wire. The soft manganese steel wire gave rather a lower modulus, namely, $1,671 \times 10^6$ gramme per square centimetre.

These numbers are lower than either steel or iron. Iron has a modulus of $1,861 \times 10^6$, and steel varies from 1881 up to $2,049 \times 10^6$ for pianoforte wire. Copper has a modulus of $1,195 \times 10^6$, and platinum wire of $1,700 \times 10^6$ grammes per square centimetre; so that manganese steel wire has about the same modulus of elasticity as platinum.

The breaking strain of the No. 19 annealed manganese steel wire I found to be 124lb., with an elongation of 4 centimetres in the length of 22 centimetres under trial. This corresponds to a breaking stress of 48·8 tons per square inch, or 768×10^4 grammes per square centimetre, with 18 per cent. elongation.

The *hard* manganese steel wire had a far higher tenacity and much less elongation. The same size, No. 19 wire (0·038in., or 0·98 millimetre diameter), broke at 280lb., equivalent to 110·2 tons per square inch. This is equivalent to $1,735 \times 10^4$ grammes per square centimetre. A second experiment gave 109·4 tons per square inch, and two independent tests, kindly made for me with an admirable dynamometer by Mr. Ivatt, engineer to the Great Southern and Western Railway Company, Dublin, at their works at Inchicore, yielded 107·9 and 110·7 tons per square inch. The elongation here was scarcely perceptible, being little over 1 per cent.

The breaking strain of ordinary steel wire varies from 54 to 63 tons per square inch. The best pianoforte steel wire is 150 tons per square inch. A comparative experiment I made with common pianoforte wire (0·027in. diameter) gave me 117 tons per square inch, or $1,851 \times 10^4$ grammes per square centimetre, and had the manganese wire been of the same gauge, its tenacity would probably have been about equal to this.

The profound change in the structure of this alloy produced by annealing through sudden cooling is remarkable, the breaking stress of the unannealed wire being more than double that of the annealed, and its intensity nearly eighteen times less.

I now come to the *electric resistance* of the wire. The length of the No. 19 wire I tried was 5 metres. This had a resistance of rather more than an ohm per metre. The resistance of the annealed and unannealed wire was exactly the same. Precisely speaking, the specific resistance of manganese steel at 15deg. C. is 0·000078 of an ohm, or 78 microhms per cubic centimetre. This is very high. The specific resistance of iron is 9,827 C.-G.-S. units, and of German silver 21,170 units per cubic centimetre. So that the resistance of manganese steel is 3½ times that of German silver. This high resistance and high melting point seemed to point to a useful application of this material for the construction of resistance coils for electric lighting and other purposes. I therefore determined how far the resistance was affected by change of temperature.

Some four metres of the wire were immersed in an oil bath and the resistance determined for every 10deg. C. rise of temperature up to 215deg. C. The resistance of 384 centimetres length of No. 19 wire at 15deg. C. was 4·22 ohms, or ·000078 absolute units per cubic centimetre—that is to say, 78 microhms per cubic centimetre. The resistance rose steadily up to 215deg. C., when it was 5·37 ohms, or 99·8 microhms per cubic centimetre, an increase of 27½ per cent., or 0·136 per cent. for 1deg. C.

This is a high increase, but not so high as iron. A specimen of commercial iron wire was tested for comparison. The resistance was found to be 13 microhms per cubic centimetre at 15deg. C., and rose to 26 at 215deg., an increase of 100 per cent., or a percentage increase of 0·5 for 1deg. C.

Nickel wire was also examined. The increase of resistance of nickel for increase of temperature I could not find in any tables. Possibly it has not hitherto been determined. Nickel wire (not pure) I found had a specific resistance at 15deg. C. 14·1 microhms for 1 cubic centimetre, increasing to 25·4; at 215deg. an increase of 80 per cent. for 200deg., or 0·4 per cent. for 1deg. C., not quite as large as iron.

German silver wire was also compared. The specimen tried had a specific resistance of 26 8 microhms for 1 cubic centimetre, and increased 7·8 per cent. for 200deg. C., or 0·04 per cent. for 1deg. C.

Hence the resistance of manganese steel is three times that of German silver, and its increase for temperature coefficient only one-third that of iron.

I have, in conclusion, to refer to some experiments I made last year to compare the coefficient of induced magnetism of manganese steel with that of soft iron. I had not then seen Dr. Hopkinson's well-known paper on the "Magnetisation of Iron," in which the magnetic induction in different kinds of manganese steel is given; and I may add that the experiments of Prof. Ewing on the magnetisation of iron in strong fields, which he proposed to extend and has since extended to manganese steel, were made subsequently to my attempt. The results I obtained did not differ very materially from those found by Dr. Hopkinson, the magnetic susceptibility of manganese steel in a powerful magnetic-field being about the same as that of ferric oxide in the same field.

Finally, a series of experiments were made to ascertain whether the presence of this percentage of manganese deprived the steel of other well-known physical properties.

As might be expected, manganese steel does not exhibit the magnetic tick or sound heard on the magnetisation of iron and steel, and which is well heard in nickel and most strikingly in cobalt. Nor, of course, does a bar of manganese steel show the slightest change of length on the passage of a magnetising current round it. A far more interesting question was whether this body would exhibit the anomalous expansion on cooling from a red heat and the sudden afterglow which I discovered some time ago occurred in iron, and notably in steel wire. The temperature at which the anomalous expansion and the afterglow occurs I have shown is coincident with the temperature when the magnetic state of iron and steel destroyed by a high temperature is resumed on cooling. Careful experiments with manganese steel wire established the fact that no trace of this anomalous deportment on cooling occurred with this substance. There was no sudden expansion, but a steady contraction; no afterglow, but a steady cooling from a white heat downwards.

Wires of various non-magnetic metals were also tried, platinum, copper, German silver, silver and gold. Not one of these exhibited the anomalous expansion nor the afterglow. Nickel wire, it is true, likewise did not exhibit it—at least, to any sensible extent; but the magnetic state of nickel is lost at a temperature of 330deg. C., considerably below a red heat. Cobalt wire would, I have no doubt, be found to exhibit phenomena analogous to steel; but I have not yet been able to obtain a specimen.

Here, then, we have some new and singular evidence of the close connection between the magnetic state and the molecular condition of a magnetic metal. At a certain critical temperature a magnetic metal loses its magnetic character, which is accompanied by a change of volume of specific heat, and of thermo-electric behaviour. These changes do not occur in non-magnetic metals.

In fine, when we remember that 13 per cent. of a more magnetic metal mechanically mixed with iron or steel produces but a slight change in the magnetic deportment, and then consider the profound change wrought by an alloy of steel with 13 per cent. of manganese (itself a fully magnetic body), interesting questions arise as to why chemical union should act in this manner. Manganese steel has about the same magnetic susceptibility in ferric oxide; German silver, in like manner—which is an alloy of the magnetic metal united with brass—is magnetically inert. More experiments are required on the magnetic behaviour of the different alloys of the magnetic metals. The effect of an alloy in increasing the electric resistance of a metal is well known; with manganese this effect is strikingly great. A steel whose percentage of manganese rises from 0·72 to 1·58, or say double, increases in resistance over 34 per cent.

The practical as well as theoretic interest of this alloy of steel is considerable. Obviously a body so tenacious, so hard, and so magnetically inert, ought to have many practical applications. Watches could be made non-magnetisable by springs of manganese steel. The time may not be far distant when a suitable alloy of manganese with steel may be economically and safely used in the construction of ironclad vessels, and anchors and chain cables, so that whilst keeping the strength of our modern ships of war we may return to the magnetic safety of wooden vessels.

ON THE MODE OF FORMATION OF HYDROGEN PEROXIDE DURING THE ELECTROLYSIS OF DILUTE SULPHURIC ACID.*

In a previous paper (*Wied. Ann.*, XXIV., p. 183, 1885) the author has investigated the mode in which the formation of S_2O_7, H_2O_2, and O_3 during the electrolysis of dilute sulphuric acid depends on the temperature, the duration and density of the current, and the degree of concentration of the acid. He found, as Berthelot had previously done, that H_2O_2 is formed only if the degree of concentration of the acid exceed 60 per cent. The author assumed it as obvious that the peroxides formed proceed from the anode, though owing to the form of the decomposing vessel this might be at first doubted. On the other hand, Dr. M. Traube, of Breslau, assumed (*Chem. Ber.*, XIX., p. 1,111, 1886) that H_2O_2 was never formed at the anode, but always at the cathode only, while the O_2 dissolved in the liquid—or in any

* Abstract of paper, "On our Knowledge of the Mode of Formation of Hydrogen Peroxide at the Anode during the Electrolysis of Dilute Sulphuric Acid," by Dr. Franz Richarz, of Berlin (*Wied. Ann*, XXXI., p. 912, 1887). Translated by Mr. E. F. J. Love. A communication from the author to the Electrolysis Committee of the British Association.

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other way present—was reduced by 2 H to H_2O_2. The author has accordingly undertaken fresh experiments respecting the source of the H_2O_2 found by him.

The presence of small quantities of H_2O_2 in tolerably concentrated sulphuric acid, simultaneously with S_2O_7, could be proved by the decolorising of potassium permanganate ($KMnO_4$) and by the yellow coloration of titanium dioxide (TiO_2). If a greater quantity of H_2O_2 be present it was susceptible of further demonstration, under the conditions stated, by the formation of perchromic acid. The S_2O_7 was determined by the oxidation of ferrous sulphate.

The electrodes were placed in the legs of a U-tube; the anode was a thin platinum wire. With acid of strength exceeding 60 per cent. S_2O_7 and H_2O_2 showed themselves close to the anode after the current had been closed for a short period, while at the same time no trace of either was found near the cathode. After longer duration of the current the quantity of H_2O_2 at the anode became very considerable. But this only occurred when S_2O_7 had already shown its presence in the fluid.

The author has succeeded in showing that the H_2O_2 discoverable at the anode owes its origin to a purely chemical process. In a quantity of acid of about 40 per cent. strength a considerable amount of S_2O_7 was produced by electrolysis. This liquid, which contained no H_2O_2, was brought up to a strength of about 70 per cent by the addition of pure H_2SO_4, avoiding rise of temperature. At this point H_2O_2 was suddenly formed in the liquid, quite as rapidly as during the electrolysis of 70 per cent. acid. In sulphuric acid of this concentration, S_2O_7 cannot therefore exist without the formation in a short time of considerable quantities of H_2O_2, since atoms of active oxygen become separated from the S_2O_7 and oxidise H_2O to H_2O_2. That the oxidation of H_2O to H_2O_2 at the anode is not a primary process is made clear by the fact that SO_4—not O—is the anion, the active oxygen O is a secondary product.

Traube's theory of the constitution of H_2O_2 (l.c.) is finally refuted by the indisputable fact that the H_2O_2 makes its appearance at the anode, and is produced by the oxidation of H_2O.

ON ELECTROLYTIC CONVECTION CURRENTS.*

According to Helmholtz's theory of electrolysis and convection currents (the connection between which he demonstrated in the Faraday Memorial Lecture to the Chemical Society of London, April 5th, 1881), the existence of continuous currents in acidified water, under the action of electromotive forces less than about 1·5 Daniell, is explained by the occlusion of oxygen and hydrogen, especially the latter, in the electrodes, and by the charging of neutral oxygen dissolved in the liquid with negative electricity at the cathode; in consequence of which this oxygen either combines with two positive hydrogen atoms to form water or starts on a new migration as an anion towards the anode. Products demonstrably due to convection currents would *not* make their appearance in the liquid. The author is of opinion that H_2O_2 and H_2O may possibly be produced by the reduction of O_2, following the analogy of the mode of formation of H_2O_2 at the cathode by convection currents, shown by M. Traube to occur under certain conditions. In fact, after the current of a Daniell element has been passed for several days between platinum electrodes the presence of H_2O_2 in the liquid can be demonstrated, and it is even susceptible of quantitative estimation.

In order to answer the question, to what extent is the production of current due to the formation of H_2O_2? the strength of the convection-current was measured, and the quantity of H_2O_2 calculated which the current would have to yield during its continuance, in order that its production should depend only on the formation of H_2O_2. In this case a molecule of H_2O_2 is derived from every molecule of water which the current would decompose by regular electrolysis according to Faraday's law; we must, therefore, figure to ourselves the formation of H_2O_2 as occurring in some such way as the following:—Neutral oxygen $O\,{}^{-}_{-}\cdot{}^{+}_{+}O$† comes in contact with the cathode; it there gives up a positive unit of electricity, takes up a negative unit, and then combines with two positively charged hydrogen atoms to form hydrogen peroxide.

$$H+.-O-.+O-.+H.$$

But these same quantities of electricity would also be transferred from the cathode to the liquid, or *vice versâ*, if, as happens in the decomposition of a molecule of water, a +H is transformed into a −H, and escapes in combination with another +H as neutral hydrogen. In this way the total quantity of H_2O_2 which the current concerned could produce was calculated, and the quantity of H_2O_2 actually formed compared therewith.

Experiments with cathodes of different metals and an electromotive force of one Daniell showed that with annealed foil the occlusion of hydrogen at first takes the principal share in the production of the current; but if the charge of hydrogen on the cathode increases, the formation of H_2O_2 plays the chief part. If the metal of the cathode be previously fully charged with hydrogen, the convection current must be ascribed solely to the formation of H_2O_2, and the existence in the liquid of about $\frac{9}{10}$ths of the H_2O_2 calculated from the current strength may be proved.

Whether a definite electromotive force is needed for the formation of H_2O_2 has yet to be determined.

* Abstract of a paper on "Convection-Currents," by Dr. Franz Richarz, Verhandl. d. physik. Gesellsch. z. Berlin, 1887, No. 12. Translated by Mr. E. F. J. Love. A communication from the author to the Electrolysis Committee of the British Association.

† Misprinted in the original $O=\cdot{}^{+}_{+}O$.

After the reading by Dr. Lodge of the report of the Electrolysis Committee (for which see our issue of October 7th, page 464), Sir W. Thomson made the following remarks:—

Sir W. Thomson: A rule of the British Association exists according to which the report of a committee is not subject for discussion. That, of course, applies to the ordinary reports of ordinary committees; but this is not an ordinary report of an ordinary committee. It is a very extraordinary, and I think I may add a very extraordinarily valuable report. I am sure you will all agree with me in that opinion, and although we have placed second on the line that the section is to take the discussion on that report, I am sure you wish me to let nothing intervene between the reading of the report and the according to Prof. Lodge a vote of thanks for presenting so able a document to the association. It has been a most exhaustive philosophical treatment of all the aspects of the question, and seems to be the *beau ideal* of a report on a subject under investigation by a committee the main object of which is to promote research into all points that can be scientifically raised in reference to any part of the subject. And I must say I cannot think of any part of the question that has been touched upon by Prof. Lodge with reference to which the proper question has not been put in the proper scientific manner, to show how experimental research may come in and settle a question which by *a priori* reasoning we are unable to decide.

A METHOD OF TELEPHONIC COMMUNICATION BETWEEN SHIPS AT SEA.*

In February, 1883, while investigating at Berlin the experiments of Colladon and Sturm as to the velocity of sound through the waters of Lake Geneva, the thought occurred, "Why not make a practical use of water as a means of communicating between vessels at sea? Several methods were immediately devised, with the valuable suggestions of Dr. Koenig, Assistant in the Physical Laboratory of the Royal University, but actual experiment had to be deferred until a return to the United States in June of that year. At that time apparatus was prepared, and a course of experimentation has since been carried on to the present time, with more or less interruptions and more or less success. It may possibly prove interesting to learn of the methods employed and of the progress made. Further, perhaps, in the experiments something suggestive may be found which will enable inventors to follow out in detail the system proposed. As far as the writer knows, the thought, the experiments, and the whole scheme antedates all methods which have been proposed for fog signalling by telephone at sea.

Briefly, the plan was as follows:—A sound-producing apparatus was to be attached to each vessel, and to be worked under the surface of the water. In times of fog or night a code of signals would be produced by it which would be transmitted in all directions through the water, with a velocity four or five times that in the air. Each vessel, in addition to the sound-producing apparatus, would be provided with a sound-receiving apparatus, which would take up out of the water the signals arriving from neighbouring vessels. All of us remember when, as boys in swimming, how distinctly the sound of the striking of stones together under water was heard. Just so distinctly it is possible to send musical tones from one ship to another.

For steamships, the sound-producing apparatus was designed to be a steam fog-horn or whistle, specially constructed to sound under water, and to be heard at least from six to eight miles. From the nature of its tone it would be easily distinguishable from other sounds always more or less present under water, such as from breakers, waves, &c. With such whistles a Morse alphabet of long and short blasts and pauses was to provide a means of extended communication, while a simple universal code would indicate a ship's course. Since ignorance of the very presence of a ship, rather

* Paper read before the American Association for the Advancement of Science, at the New York Meeting, by Prof. Lucien J. Blake.

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than incorrect estimates of her course, has been the principal cause of ocean collisions, the simple hearing of the sound would prove a most excellent general safeguard. Bell buoys were to have a second bell added under water, while lightships, light-houses, and any headlands might also be provided with submerged bells which could be rung from the shore, if necessary. Sailing craft, both large and small, would have bells, and since an ordinary locomotive bell can be heard, according to my experiments, at least two miles under water, such simple means would seem to afford sufficient limits for protection for such vessels.

As to the receiving apparatus, with which each vessel was to be provided, the original plan of 1883, and which has not been changed, was to employ some form of telephone acting as a transmitter under water and connected with a receiver within the vessel. The surface of the transmitter exposed to the water, and which must receive the sound waves, must be protected against ice, barnacles, heavy waves, &c. One design was that one or more vertical pipes in different parts of a ship were to extend from the vessel's interior through the hull, near the keel, and be open to the free admission of water at their lower ends ; their upper ends were to extend within the vessel a little way above the keel, and were to be plugged so that the water could not overflow into the vessel. These pipes would then provide columns of water always still, and would communicate directly with the water outside. Sound would then enter and pass up these pipes, and would encounter microphonic transmitters placed suitably in them. Wires from the transmitters could run to a small room, secluded wherever convenient in the ship, away from disturbing noises, and here telephone receivers would be placed, and observers stationed in night or fog.

For small craft it was found by my experiments that a pipe shaped much like an old-fashioned powder horn, with a thin flexible membrane stretched tightly across its broad end, made a successful receiver. With the small end made to fit the ear, and the diaphragm end only a few inches below water, the sound of a hand bell has been received nearly a mile distant. Colladon and Sturm used a somewhat similar receiver, and heard a heavy bell ten miles.

Such is the outline of the plan as conceived and experimented upon in 1883. In the long-distance experiments a locomotive bell or some form of gong was used ; while in the laboratory various automatic devices for producing sound under water were employed. First, it was necessary to devise the best form of receiving apparatus. Nearly all existing forms of telephones were first tried. The Bell receiver and the Blake transmitter will not work under water. The first success was obtained by a form of transmitter resembling the Ader. A cigar box cover, from its good resonant qualities, formed the diaparagm ; to this four small carbon blocks were screwed at the four corners of the square ; four cylinders 2in. long, of electric light carbon, formed the sides of the square and rested with their taper ends lightly on the blocks ; the carbons were put in series with a battery and Bell receiver. With this transmitter, with the help of E. W. Rockwood, Assistant in Chemistry, at Cornell, signals were transmitted and received between boats one-half mile apart on the Taunton River in 1883. The water, however, would spoil the contacts of the transmitter after a use of about 15 minutes. To obviate this the carbons were attached to the inside of a resonance box, which was then made water-tight. This. however, failed to make the transmitter markedly better. The transmitter was weighted to float at different depths, but in all positions, as regards the approaching sound waves, it received equally well. Up to about half-a-mile the signals from an ordinary dinner bell were distinctly heard. The higher overtones of the bell seemed to be quenched so that the sound came muffled. The experiments seemed to indicate that a transmitter dependent upon a variable contact might yet be made which would work with satisfaction. This line was consequently followed up for the next year or so. It might be stated that, later, with apparatus similar to that already described, signals were transmitted between boats a mile distant off Stone Bridge, near Newport, R.I., in the same summer of 1883, through a rough sea and in a dense fog. The latter attendant circumstances have nothing to do, of course, with the principles of sound transmission and reception, but gave encouragement that the method was independent of the state of the water outside.

From this time various forms of microphonic transmitters were constructed, and experiments on Long Island Sound and on the Wabash River, at Terre Haute, Indiana, were conducted as limited opportunities of time permitted.

In September, 1886, Mr. Jesse Kester, a young practical electrician, became interested, and with his valuable aid, the experiments have been carried on with many interruptions to the present summer.

One form of transmitter which has worked fairly well consists merely of a diaphragm having within itself the elements of a microphone. It is placed in simple voltaic circuit with a Bell receiver. This diaphragm is made out of hard carbon in granules about the size of the smallest shot. A paste is made of these with rubber cement, and this, in a mould and die under heat and pressure, becomes a hard, thin, elastic disc. The electrical resistance is very high, and can be altered according to the per cent. of rubber cement present. This disc or diaphragm takes up the sound vibrations excellently well out of the water, the rubber giving the requisite elasticity. The diaphragm vibrations produce corresponding varying pressures at the innumerable points of contact of the carbon granules. The action is, of course, similar to that of a multiple contact transmitter.

One difficulty, however, was found to lie in the gradual deterioration of elasticity under the action of salt water. Further, the brittleness of this diaphragm, especially when the carbon granules were comparatively large, or in large proportion to the cement, rendered it liable to rupture by a strong wave, or by any foreign substance striking it under water. A paste with celluloid was much tougher, and seemed a slight improvement. As a transmitter in the air this worked very nicely, and of course without the buzzing of the Blake. But no attempt was made to develop it further for this purpose.

To avoid this brittleness diaphragms of wood and metal were tried with one or more carbon buttons. These buttons, however, differed from the Blake or Edison in that the change of pressure which produced the undulatory currents operating the receiver did not occur at the surface where the button made contact with platinum or with other carbon pieces as in these latter, but the variations of pressure took place within the button itself. To do this these variable-pressure buttons were made as follows :—Fine granules of retort carbon were sorted to uniform size through a sieve with meshes about 900 to the square inch. These were then first plated with copper, then with silver, and thirdly with a thick coat of platinum. These different platings seemed necessary to make the platinum "stick" (adhere), so to express it. At the end of the platings there remained grains of high electrical resistance, exposing many points and irregularities for contacts. These grains, in different proportions, were mixed with rubber cement and a set of hard elastic balls, about the size of peas, and thick discs moulded out. These were included in a voltaic circuit with a Bell receiver, and the diaphragm rested lightly against them. Such an arrangement proved very sensitive to vibrations of the diaphragm under water. In the laboratory experiments a watch on a floating board could be heard through the water about 3ft. distant.

On the river, however, through a long distance, these did not seem sufficiently satisfactory. This difference in action between a long and a short distance, led to the thought that, as the advancing front of the sound wave is an arc, approaching in curvature nearer and nearer the tangent to its circle, a large diaphragm would receive more sonorous energy and thus probably prove more effective. This is the point to which the experiments have now been carried, and the next trials will be with a diaphragm 18in. square.

It is believed that sufficient has been done, however, to show that the complete solution of this interesting and valuable practical scheme will lie probably in the telephonic method just described or in some modification of it ; at least, by this method, in October, 1885, signals were transmitted and received 1½ miles on the Wabash River from a locomotive bell around three or four windings of the river, so that the operators were out of each other's sight, and the sound could not be heard through the air, yot could with fair distinctness through the telephone.

It is hoped that experimenters may find in the above methods and experiments enough to encourage further investigations, and with this end in view and from the fact that the writer is, for the present, by circumstances, turned to a different line of investigation, this article has been prepared, and the experiments thus for the first time made public.

COMPANIES' MEETINGS.

The Brazilian Submarine Telegraph Company (Limited).

The 28th ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on the 2nd inst., under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice calling the meeting.

The CHAIRMAN reminded them that at their meeting a year ago he had to condole with them on a diminution of their receipts, telling them at the time that the depression of trade which had affected all the world more or less had at last affected their undertaking. He was glad to be able to state that during the half year to which the report now submitted referred the receipts had been larger than they had ever been since the Company was started. They amounted to over £100,000 for that period. That enabled the directors to declare the usual dividend of 6 per cent., and a bonus which brought up the dividend for the year to 7 per cent. That was a subject of congratulation to the Directors as showing the

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prospects and condition of this undertaking, and he was happy to be able to inform them that the receipts since the close of the half year had continued to increase. The plant of the Company was all in good order. The reserve fund now amounted to £112,000, it having been increased to that amount during the last half year by the sum of £25,000. In their expenditure there had been an increase of £326, but that was accounted for in a great measure by the increase of the traffic, and also by the fact, which he had alluded to at the last meeting, that they had had to meet (which could not be done without some expenditure) attempts at creating competition. A shareholder had written to him asking him to say something about the African Direct Telegraph Company, in which the Brazilian Submarine Company was largely interested. He might say in general terms that that company had been in operation for only a very short time, that the receipts were improving, and that they were now about paying expenses. Therefore, they might hope that after a little while that would become a source of profit to the Company. But he must at the same time remind them that when they embarked in the African Direct Company they did it very much as a matter of strategy, to prevent a rival from coming into their district, and not as a pecuniary speculation. He concluded by moving the adoption of the report and the declaration of the dividend and bonus recommended.

The VICE-CHAIRMAN (Sir James Anderson) seconded the motion.

Mr. JOHN H. NEWMAN thought it would have been better, in view of the termination of their concession, if they had transferred the amount now proposed to be distributed as bonus to the reserve fund, so as to strengthen their position to meet the opposition which he felt sure they would encounter at the end of their term.

The CHAIRMAN said it was quite refreshing to him as Chairman to hear such observations, because many of the shareholders were probably aware that he had been fighting the cause of a larger reserve fund. He thought that Mr. Newman must have forgotten for the moment that the management had already duplicated their whole system of cables by means of an accumulated reserve fund—that was to say, with the exception of a very small portion of debenture capital which they were paying off by degrees. The reserve fund now, as he had already said, stood at £112,000. He therefore did not think the Directors would have been justified in withholding from the shareholders what they had legitimately earned this year in the way of bonus. He then put the resolution, which he declared carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. FREDERICK YOULE, Sir James Anderson was re elected a Director, as was also the Hon. W. St. John F. Brodrick, M.P., on the motion of the CHAIRMAN, seconded by Mr. H. D. GOOCH.

Mr. NEWMAN then proposed, and Mr. WM. HUNT seconded, a resolution for the re-election of Mr. Henry Dever and Mr. John Gano as auditors for the ensuing year, at a remuneration of £50 each, which was unanimously agreed to.

Dr. H. ELLERY TREWHELLA proposed a vote of thanks to the Chairman and Directors, and expressed a hope that they might be able hereafter to present the shareholders with an even more favourable record.

Mr. NEWMAN seconded the motion, which was unanimously passed.

The CHAIRMAN, in acknowledging the vote, said that he thought the duration of the meeting was the best test of the management of the Directors that could be given.

The meeting then separated.

Woodhouse and Rawson (Limited).

The statutory meeting of this Company was held on Wednesday, at 20, Bucklersbury, E.C., Lieut.-General Sir John Stokes, K.C.B, in the chair.

The SECRETARY having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, this is merely a statutory meeting; there is no formal business before the meeting. There are, however, one or two points that may be interesting to you to hear. Mr. Ashby has been elected a Director; he represents a very large number of shareholders. I regret to tell you of the death of Mr. Woodhouse. This took place on September 21st, after a long illness. As Mr. Woodhouse has not attended to the business for a very long time it will make no difference in carrying it on. The Directors wish to express their regret at his death. That is the only communication I have to make to you. I do not know whether any gentleman wishes to ask any question.

Mr. GEORGE SMITH: I think, Mr. Chairman, as shareholders, we would like to know something of how the business is going on, whether all the shares have been taken up, whether the work is progressing satisfactorily, and whether we may look forward in due course to our 10 per cent. dividend. Any information you can give us will be very acceptable to the shareholders, I am sure.

The CHAIRMAN: We are doing our business, and carrying out the purposes of the Company announced in the prospectus. The whole of the shares have been taken up. We have already business in hand which justifies us in hoping to be able to declare a dividend when the time comes. It is early yet, and it is impossible to say whether it will be 10 per cent., or what it will be.

Mr. SMITH: I think, Sir, it was expressed in the prospectus.

The CHAIRMAN: Oh, yes. There has been an increase in the sale of electrical supplies during the last two months that has been considerably greater than the corresponding period of last year, and that two months is the period we have been working. Arrangements have been made under which our lamps are being made and sold on satisfactory terms. Our position as a manufacturing company has considerably improved, and we are receiving large orders. I think that is a satisfactory statement to make.

Mr. SMITH: I suppose the litigation is at an end?

The CHAIRMAN: We have no litigation.

Mr. RAWSON: I will explain that the litigation is at an end excepting this, that we have the right to appeal to the House of Lords for a certain length of time, and, of course, it depends how matters go for the next few months whether we appeal or not. If we appeal it has nothing to do with Woodhouse and Rawson (Limited), it has only to do with Woodhouse and Rawson.

Mr. SMITH: It would be a great boon to this Company if we could make lamps in this country. They are being made abroad.

Mr. RAWSON: Yes, no doubt.

The CHAIRMAN: I think that is all, gentlemen, and I need not detain you any longer.

Mr. SMITH: Shall we have half-yearly meetings after this?

The CHAIRMAN: Annual meetings.

Mr. SMITH: When will the next annual general meeting be held?

The CHAIRMAN: I cannot say; there is nothing arranged for that. In October next year probably, when the accounts will be made out.

The proceedings then terminated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 28st October amounted to £4,173.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of October was 3,416, estimated to produce £2 900, against 2,782 messages, producing £2,413, in the corresponding month of last year. The traffic receipts for the month of July, estimated to produce £2,600, realised £2,607.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of October amounted to £2,276, against £2,038 for the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October, amounted to £53,089, and to £49,374 in the corresponding period of 1886.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October, amounted to £40,018, and to £37,185 in the corresponding period of 1886, bing an increase of £2 833.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 28th October, 1887, were £3,362, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended 31st October are £2,742, as compared with £2,053 in the corresponding period of 1886.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. NOV. 2.		BUSINESS DONE WEEK ENDING NOV. 2. Highest.		Lowest.	
Anglo-American	39½,	40½	.....	40½	.....	39½
Do. Preferred	65½,	66½	.....	66½	.....	64
Do. Deferred	14½,	15½	.....	15½	.....	14 11-16
Brazilian Submarine	11½,	11¾	.....	11¾	.....	11½
Cuba	11¾,	12¼	.....	12¼	.....	—
Do. Preference	18,	19	.....	—	.....	—
Direct Spanish	2⅞,	3¼	.....	—	.....	—
Do. Preference	8,	9	.....	—	.....	—
Direct United States Cable	9½,	9¾	.....	9¾	.....	9½
Eastern Telegraph	11,	11¼	.....	11 5 16	.....	11¼
Do. 6 per Cent. Preference	14,	14½	.....	14¾	.....	14½
Do. 5 per Cent. Debentures, 1899	109,	109	.....	—	.....	—
Eastern Extension	11½,	11¾	.....	11¾	.....	11½
German Union	10½,	11	.....	—	.....	—
Globe Telegraph and Trust	5⅞,	5¾	.....	5 13-16	.....	5⅝
Do. Preference	13½,	13⅝	.....	13¾	.....	13½
Great Northern	13½,	14	.....	13 13-16	.....	13⅝
Indo-European	36,	38	.....	—	.....	—
Reuter's	8,	8½	.....	8½	.....	—
Submarine	170,	180	.....	—	.....	—
West India and Panama	⅝,	¾	.....	—	.....	—
Do. 1st Preference	9½,	10	.....	9 13-16	.....	9½
Western Brazilian	7⅛,	8½	.....	8	.....	7⅛
Western Union 7 per Cent. 1st Mortgage	117,	123	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	101,	104	.....	—	.....	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅜,	½	.....	—	.....	—
Oriental	⅛,	¼	.....	—	.....	—
United Telephone	11¼,	11½	.....	11½	.....	11¼
United River Plate	4½,	5	.....	4 15 16	.....	—

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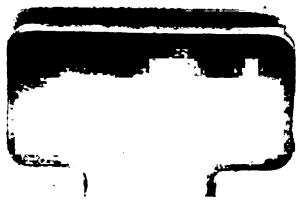

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